PHILADELPHIA:
CAREY & LEA—CHESNUT STREET.

1831.

THE NATURE AND PROPERTIES OF THE SUGAR CANE;

WITH

PRACTICAL DIRECTIONS

FOR

THE IMPROVEMENT OF ITS CULTURE,

AND THE

MANUFACTURE OF ITS PRODUCTS.

BY GEORGE RICHARDSON PORTER.

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SKERRETT—NINTH STREET,
PHILADELPHIA.

TO

THE MOST HONOURABLE

RICHARD PLANTAGENET GRENVILLE,

MARQUESS OF CHANDOS,

CHAIRMAN,

AND TO

THE GENTLEMEN COMPOSING THE STANDING COMMITTEE

OF

WEST INDIA PLANTERS AND MERCHANTS,

THIS VOLUME IS

(BY PERMISSION)

MOST RESPECTFULLY INSCRIBED.

PREFACE.

Few subjects are of greater consequence to the commerce of the British empire than the sugar trade, whether considered with reference to the vast amount of capital which it employs, or the extent of the public revenue which it yields. The prosecution of this trade with our Western dependencies acquires, likewise, great importance, as forming an ample nursery for seamen, and opening a steady and extensive market for goods of British manufacture.

During the past and present centuries, the trade in sugar has increased in an eight-fold proportion, giving employment to a class of merchants, who, in regard to their respectability and intelligence, are second to none of the great mercantile interests, of which this country can so justly boast.

Under these circumstances, it is certainly surprising that no publication of adequate authority is to be found in the English language, exclusively devoted to the subject; and even those works, in which alone information could hitherto be found, are of too remote a date to communicate any of the numerous and important improvements for which, during the past half century, the arts have been indebted to the scientific discoveries of European philosophers.

In the attempt to supply this deficiency, the author of this Work has not relied alone upon his own experience, but has carefully and diligently availed himself of every source of knowledge to which he could obtain access; not only consulting many very experienced practical sugar planters, but profiting freely of information derived from the various works to which he has been able to refer upon the subject. Some of these have issued from the presses of both the East and West Indies, and for several others it will be seen that he has had recourse to French authors. Among the latter class, the name of Dr. Dutrone has long been held in high and well deserved estimation. Throughout his voluminous work, that author evinces a spirit of the most enlightened intelligence, and it can hardly be too much regretted that circumstances should have arisen to destroy the system of manufacture, which, with so much pains, he had suc-

cessfully founded in St. Domingo. Appreciating thus highly the authority of Dr. Dutrone, the author has borrowed largely from his experience and reasonings, and has been glad to adopt from his work the physiological information concerning the sugar cane, which will be found in the earlier Chapters of this Volume, as well as his statement of the plans in use among the French sugar planters at the time he wrote, contrasting those plans with his own more scientific suggestions. The terms used by Dr. Dutrone are not all of them strictly in agreement with the researches of more modern chemists; it has, nevertheless, been thought adviseable rather to retain these terms than to run the hazard of obscuring his meaning, since, although their designations may be deemed antiquated, or even incorrect, the *things* remain, and the reasoning is equally apposite, by whatever names they may be called.

Among the living authorities to whom the author has had recourse, he is most indebted to Major Moody, of the Royal Engineers, a gentleman who through life has ardently improved the advantages derived from a scientific education, and who has enjoyed opportunities for applying his attainments practically and extensively in the management of sugar plantations in the West Indies. The author has had the singular advantage of Major Moody's suggestions throughout the progress of

the work, and eagerly embraces this opportunity of acknowledging how largely he has benefited by the assistance.

The attention of the author has been more particularly called to the subject of this work by the circumstance of his having obtained the grant of a patent for an invention, which he doubts not will be found eminently useful to the sugar planter in the successful and economical manufacture of his produce. A description of this patent, and the reasons for entertaining a sanguine view of its success, will be found in that section of the volume which is devoted to the description of various improvements; and the author is farther borne out in this view, by the approving testimony of a most intelligent and much lamented planter of Grenada lately deceased, who had put the invention to practical and successful use on his plantation.

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authorities of ancient and modern times, lead to the conclusion, that China was the first country in which the sugar cane was cultivated, and its produce manufactured; and it is tolerably well ascertained that the inhabitants of that country enjoyed its use two thousand years before it was known and adopted in Europe.

Sugar appears to have been one of the last known of the Eastern products. There is no mention made of it in the history of Ancient Egypt, Phœnicia, or Judea. The Greek physicians are the first who have spoken of it under the name of Indian salt.*

The sweet taste, and other characteristics, which are assigned to it by Dioscorides and Pliny, leave no doubt that it was what we now denominate sugar-candy.

It will not excite surprise, that the knowledge and adoption of the use of sugar, were so slow in their progress, when the retarding causes are taken into consideration.

The Indians would, of course, be jealous of bringing the cane itself to the countries with which they traded; since, had the cultivation of it been introduced into

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Pliny says, Saccharum et Arabia fert sed laudatius India; est autem mel in arundinibus collectum, gummi modo candidum, dentibus fragile; amplissimum nucis avellanæ magnitudine ad Medicinæ tantum usum.

these places, it would have rapidly spread, and deprived its first cultivators and manufacturers of a most lucrative branch of their trade.

The frail vessels in which the ancient merchants ventured to embark, and the very small space they could allot to their cargoes, made it strongly their interest to load their barks with goods of the least weight and bulk, in proportion to their value. Sugar did not possess these advantages in an equal degree with many other descriptions of merchandise, and the cane, even much less than sugar.

The Indian salt was brought to Greece and Rome, from India within the Ganges, and Arabia; but it was not cultivated or manufactured in these countries. The cane then only grew in the islands of the Indian Archipelago, in the kingdoms of Bengal, Siam, &c. and the sugar that was produced from it, passed, with perfumery, spices, and other merchandise, to the countries at this side of the Ganges. It found its way into Arabia, in the thirteenth century, the period when merchants first began to visit India, and to traffic in Indian articles of commerce.

If the cane had been the produce of that part of Asia which lies between the Ganges and the Mediterranean Sea, or of Arabia or Africa, this plant, which grows so easily in all warm countries, and which reproduces itself without culture, would certainly not have escaped the observation of the different tribes who inhabited and roamed over every part of these countries. It could not have remained undiscovered, and the agreeable sweetness of its taste would have caused it to be eagerly sought after.

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The Persians, Egyptians, Phœnicians, and Grecians, who went through a greater part of Asia; and lastly, the Jews, Romans, Christians, and Mahometans, make no mention of the sugar cane, before the period when merchants first began to trade to the Indies.

The merchants learnt from the Indians who carried sugar to Musiris, Ormus, &c. that it was obtained from a reed. Upon this tradition, the inhabitants of Asia, upon this side the Ganges, sought among *their* reeds for that one which yielded so precious a product; and they believed they had found it in a kind of bamboo, called *Mambu*, the young suckers of which are filled with a sweet and agreeable juice, and it is, without doubt, this juice of which Lucian says, "quique bibunt tenerâ dulces ab arundine succos." After three or four years growth, a concrete juice exudes from the knotty parts of the *Mambu* reed: it is white, spongy, and light, and the taste is somewhat similar to that of sugar. It was called *Sacchar Mambu*, and sold under that name, and under that of *Tabaxir*, when the commerce from India was interrupted. Piso relates, that the medicinal properties of the *Sacchar Mambu* rendered it very precious and high priced.

The Arabians also endeavoured to discover sugar in the plants of their country; and the concrete juice of a kind of dog's bane, (Apocin,) known among them, under the name of Alhasser, or Alhussar, they called *Alhasser Zuccar.** Avicennes has distinguished three sorts of sugar. The *Zuccar arundineum*, which is the Indian salt, or our sugar-candy; the *Zuccar Mambu*, or *Ta-*

* Avicennes. Prosper Alpini, de Plantis Egypti. Serapion.

baxir of the Persians; and the *Alhasser Zuccar* of the Arabians.

The opinions of authors of the fourteenth and fifteenth centuries have been divided on the identity of the Indian salt, with the sugar-candy of our commerce. It has been discussed in a Latin work, under the title of *Mathioli et Manardi Epistolæ Medicinales.** Some authors have supposed, that the sugar of Dioscorides and Pliny is the same as manna;† others have confounded it with the *Tabaxir* and *Alhasser Zuccar*.

The Indians, who carried sugar to Ormus, informed the merchants, who bought their commodities, that they extracted it from a reed; but this indefinite assertion, stripped of all circumstantial details, either upon the reed, or upon the manner of obtaining the sugar from it, gave rise to a variety of opinions concerning a plant which yielded so extraordinary a product. Some thought it was a kind of honey, which formed itself without the assistance of bees;‡ others considered it as a shower from Heaven, which fell upon the leaves of the reed;§ while others, again, imagined it was the concretion of the reed, formed in the manner of gum.‖

These fanciful speculations were, in the year 1250, put an end to, by Marco Paulo, a noble Venetian, the first European who visited the country where the cane actually grew. In speaking of Bengal, he informs us, that this kingdom produces spices, ginger, and sugar, in abundance. Emboldened by the example of Marco

* Saumaise, de Mannâ et Saccharo.

† Diction. d'Hist. Valmont de Bomare. ‡ Strabo.

§ Senecæ Epistolæ. ‖ Commentators on Pliny.

Paulo, the merchants, who, before that period, had gone to Ormus for the purpose of trafficing with the Indians, now provided themselves in the country of production. Then it was they brought away the sugar cane and silk worm. Arabia Felix was the first nursery of these two productions, whence they passed into Nubia, Egypt, and Ethiopia, where sugar was soon made in abundance.

Many travellers,* in the fifteenth and sixteenth centuries, visited China, India, and the Islands adjacent. They all report, that sugar appeared in great abundance, and was, then, an article of great traffic in the various places they severally touched at. It would exceed the limits we propose to ourselves, to particularize each, nor would the inquiry possess much interest.

The precise period, after the voyage of Marco Paulo, in which the sugar cane was first introduced into Egypt and Arabia, does not appear; we can only find, from the authority of the earliest travellers,† to whose works we have obtained access, that, at the end of the fourteenth century, the cultivation of the sugar cane, and the manufacture of its juice, were spread generally throughout Arabia, Egypt, and several other parts of Africa. The testimony of various travellers, and particularly that of Giovanni Lioni, proves, that in the sixteenth century an extensive trade in sugar was carried on in Arabia Felix, Nubia, Egypt, Morocco, and

* Vasco de Gama in 1497. Pedro Alvarez Cabral in 1500. [illegible] in 1506. Odoardo Barbosa in 1515. Antonio Pigafetta [illegible], &c. Recueil de Voyage.

[illegible] Barthema, Giovan-Lioni, &c.

Ethiopia. In the latter place, it is said, the inhabitants obtained its juice by suction; since it appears they were wholly ignorant of the art of manufacturing it into sugar.* In the other countries, enumerated above, the cultivators of the cane seem to have very imperfectly prepared the juice into sugar, as it is invariably termed black and coarse.

It appears that much before this period, the sugar cane was brought into Europe. Lafitau records, that William the Second, King of Sicily, gave to the Monks of St. Bennett a mill for grinding sugar canes. But the sugar made in this Island seems to have been as inferior as that of Arabia and Egypt.

In 1420, the Island of Madeira was discovered by Don Henry, Regent of Portugal. He introduced there the sugar cane from Sicily.† It was cultivated with success there, as well as in the Canaries; and soon the sugar from these Islands, particularly Madeira, was greatly preferred to that of any other country.

The Portuguese began the cultivation of the cane in the Island of St. Thomas, (under the Line,) immediately on its discovery; and we are told on the authority of a Portuguese pilot,‡ that in 1520, this colony had more than sixty sugar manufactories. The rich inhabitants had two or three hundred negroes employed in their plantations, and there were made on the Island 150,000 arobes§ (4,650,000 lbs.) of sugar.

* Don Francis Alvarez.

† Robertson's History of America. ‡ Recueil de Voyages.

§ Each arobe being thirty-one pounds avoirdupois.

The cane was also planted in Provence,* but the cold temperature of the winter caused its cultivation to be soon abandoned. It was also introduced into Spain; and there are in the present day sugar manufactories in that kingdom, as well as in Sicily and in Madeira.

Soon after Columbus discovered the New World, one Pierre d'Etienne took the sugar cane to Hispaniola, since called St. Domingo, and now Hayti.† A Catalonian, named Michel Ballestro, was the first who expressed the juice from it; and Gonzales de Velosa the first who concentrated this into sugar.‡ The latter built a mill on the river Nigua, and at his own expense sent for skilful workmen from the Isle of Palms, (one of the Canaries,) to manufacture the sugar.§ Sloane‖ relates, on the authority of Martyr, that the cane flourished extremely well in St. Domingo, that it grew to the size of a man's wrist, and that the same root produced twenty or thirty shoots; while from those of Valence there were only five or six. He says, also, that, in 1518, there were twenty-eight manufactories on that Island. The cultivation of the sugar cane in St. Domingo extended with a prodigious rapidity, and the produce was so considerable, that we are told, the cost of the magnificent palaces of Madrid and Toledo, which were erected in the reign of Charles the Fifth, was entirely defrayed by the proceeds of the port duties on the sugar imported from Hispaniola.¶

* Miller's Gardener's Dictionary.

† Charlevoix Histoire d'Amerique.

‡ Gomara, Histoire d'Amerique.

§ Theodore de Bry.

‖ Vol. i. p. 109.

¶ Charlevoix, Vol. i. p. 421.

Father Labat* fixes the period of the first establishment of sugar plantations by the Spanish and Portuguese settlers in America, at the end of 1580; but he must certainly be in error, since it appears, that in 1518 there were twenty-eight plantations in St. Domingo alone. Nor would the Portuguese have suffered eighty years to elapse, after their discovery of the Brazils, before they introduced into that fertile country a plant so appropriate to the soil and climate; and while they saw it flourishing, and its produce manufactured in large quantities, at so short a distance from them as St. Thomas, they surely never could have been so blind to their own interest, as not immediately to foster a plant, which would yield so much benefit to their infant settlement. Father Labat asserts, on the authority of unknown and obscure travellers, that the sugar cane is indigenous to America; this appears to be without sufficient foundation, and is contradicted by the testimony of the most c[illegible]ble travellers.

M. Geoffroi† writes, that Piso considered the cane native to America; while, in the very words of Piso, which he quotes, it is distinctly stated that this plant was foreign to the New World.‡

It is certainly mentioned by Captain Cook, among the articles which the natives of the Pacific Islands brought to his ship. It is not necessary in this work

* Labat's Histoire d'Amerique.

† Matières Médicales.

‡ Licet, inquit, hæ Cannæ non sint propriæ aut domesticæ Canariarium, aut Hyspaniolæ, minus vero novæ Hyspaniæ, sed omnibus hisce provinciis advenæ et peregrinæ, quia tamen primò repertæ fuerint in Insulis Canariis, non abs re visum hic de illis agere, &c.

to enter into any investigation of its being natural or foreign to these islands. We have certainly not the slightest evidence to show that it is indigenous to the colonies of America; on the contrary, there is every presumptive evidence to disprove it. But this inquiry is, perhaps, more curious than useful.*

In 1641, sugar canes were transplanted from Brazil to Barbadoes, and thence to our other West India Islands. But the sugar made in Barbadoes was, at first, so bad, that it was considered scarcely worth sending to England, being full of molasses. In 1650, it had become much better in quality, but even then could not compete with that made in Brazil. Sugar was made by the English in the Island of St. Christopher's, in 1643; by the French, at Gaudaloupe, in 1657. When Jamaica was taken from the Spaniards by the English, in 1656, there were only three small sugar plantations on it; in 1664, the English began to improve and increase them.

In 1466, the use of sugar in England was confined to medicines and feasts, and this continued until 1580,

* It is said, that when the Europeans first visited the banks of the Mississippi, the cane was found there; and in corroboration of this, Father Hennepin is quoted, who affirms, that the banks of that river were full of canes, from thirty leagues below Maroa down to the sea. But, as this was in 1680, 174 years after the introduction of canes into St. Domingo, it is much more natural to suppose that they had found their way from the latter to the former place.

The sugar cane is said, on the authority of Francis Ximenes, Hernandez, and Piso, to have grown spontaneously, near the Rio de la Plata; and Jean de Lery affirms, that he found a great quantity of it every where near Rio Janeiro, in 1556, fifty-six years after the discovery of Brazil!

when it was brought from Brazil to Portugal, and thence to our country.*

We have now traced the steps by which the sugar cane was introduced into different parts of the world, from the period when this invaluable plant was first conveyed into Arabia. In transplanting the cane, the art of extracting its essential salt was forgotten, and the means which chance first suggested for its cultivation in Arabia, were entirely different from those practised in India.

The account which Rumphius gives of the art of crystallizing sugar, as pursued by the Chinese, shows us, that it was in accordance with the soundest principles of chemistry. It may, perhaps, be amusing, to quote his own words. "The expressed juice," says he, "is received into large boilers, placed over brisk fires; as the juice evaporates, more is added, till it becomes red and thick; then it is put in large deep earthen vessels, which are taken to a warm place. The sugar at the surface forms crystals, which are united in white clusters, called *cakes of sugar*, and that which crystallizes underneath is called *Muscovado*. The sugar is refined by being clarified in great boilers, with whites of eggs; a little chicken fat is used in the operation; it is afterwards put in large earthen plates, to crystallize. That which is obtained from the *cakes of sugar*, is very white and hard, resembling crystal; it is called *male sugar;* that which is obtained from the *Muscovado*, the crystals of which are sweeter, and less hard and fine, is named *female sugar.*"†

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* Miller's Gardener's Dictionary, folio ed.

† Vol. vi.

Rumphius does not speak of the use of lime or other alkalies, in evaporating the juice, or refining the sugar. Hence we may conclude, that the Chinese and Indians did not use them, or this naturalist, whose accuracy is so well known, would not have omitted to mention the fact.

It appears then certain, from the form in which sugar first came into Europe, in the time of Theophrastus, and even earlier, and from the state of that which Barthema and Barbosa found in the Indies, and this is confirmed by Rumphius, that the art of extracting the sugar, and refining it, consisted, among the Chinese, in obtaining it in the greatest purity, under the regular crystalline form, such as it is in the state of sugar-candy. Rumphius says, "the art of manufacturing the juice of the cane, to obtain sugar from it, is not very ancient among the Indians; they either learnt it from the Chinese, or the desire of gain stimulated them to its discovery. Even now, the Chinese are the only people who refine sugar in Java. We can now hardly doubt, that the different arts required in the cultivation of the plant, and the manufacture of sugar for domestic uses, were known by the Chinese from the highest antiquity.

Although unacquainted with the means which were first employed in Arabia and Egypt, to clarify cane juice, and to concentrate and crystallize the sugar, yet we see, by the foul and black sugar in which these countries traded, that they followed plans quite different from those of the Chinese.

The merchants who introduced the cane from India, certainly neglected to bring, also, the necessary instructions as to the methods of preparing its juice; and the

difficulties which the Arabian cultivators experienced, doubtless caused them to try the use of all kinds of ingredients for its purification, and to invent conical vessels for crystallizing and cleansing the sugar.

The Venitians introduced sugar refining into Europe at the end of the fifteenth century.* At first, they imitated the Chinese, and sold the sugar which they purified, in the shape of candy, clearing and refining the coarse sugar of Egypt three or four times over.† They afterwards adopted the use of cones, and sold refined sugar in the loaf.

Sugar refineries were soon established in all the commercial cities of Europe, and were multiplied in the same ratio with the trade of America in sugar, and in proportion to the encreasing consumption of the article. Sugar refining was first practised in England in 1544.

The method employed for refining sugar was similar to that applied to evaporate the juice of the cane. Ignorance every where presided over establishments for this manufacture; and it must always happen, that those arts, which are abandoned to unenlightened and mercenary men, remain as in their infancy.‡

Happily, a different class of men is now engaged in prosecuting the arts and manufactures, and the light of science is rapidly introducing solid improvements into every branch of human industry.

All operations in refining sugar were originally founded on crude notions, obtained from the imperfect observation of facts, of which it was impossible for

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* Miller's Gardener's Dictionary.

† Manardi Epistolæ Medicinales. ‡ Dutronc, 1789.

uneducated men to understand the causes. It is only in an intimate knowledge of the different substances of which the juice expressed from the sugar cane is composed, that reasons should be sought for the different operations to which it should be subjected.

This knowledge, in exposing the faults of processes hitherto employed, suggests the principles on which experience should rest, in the choice of new and more skilful methods.

CHAPTER II.

ON THE VARIOUS PARTS OF THE CANE, AND THEIR DEVELOPMENT.

In seeking after the most rational means of successfully cultivating the sugar cane, and converting its juice into sugar, our first inquiries should be directed to the nature and peculiar properties of the plant, and the manner of its secreting its valuable juice.

A brief investigation of this subject will certainly be useful, as it will show us, which is the valuable part of the juice, as well as the best means of improving its quality and augmenting its quantity.

The merely practical planter may, perhaps, consider this inquiry superfluous and tedious; but there is certainly much interest, and some advantage attending it. To obtain an enlightened and scientific view on any subject, we must trace it to its very source, and minutely examine all its parts. Impressed with the advantage of this inquiry, we will, previously to entering upon the subject of soils and culture, briefly examine the nature and structure of that plant, to the cultivation

of which our attention will afterwards be directed. We propose, thereafter, to treat of its vegetable economy, and the manner its juice is secreted, modified, and elaborated, and shall then proceed to describe the methods employed in its manufacture. We shall endeavour to be as concise as possible in these sections of our work, which, however, we trust will not be deemed irrelevant.

The sugar cane, *saccharum officinarum*, in botany, is a genus of the *triandria digynia* class. Its characters are these: it has no empalement, but a woolly down, longer than the flower that encloses it; the flower is bivalve; the valves are oblong, acute-pointed, concave, and chaffy; it has three hair-like stamina, the length of the valves, terminated by oblong summits, and an awl-shaped germen, supporting two rough styles, crowned by single stigmas; the germen becomes an oblong, acute-pointed seed, invested by the valves.

The assumption, that it has never been found native in the colonies of America, seems borne out by the fact, that although it flourishes there, its organs of fructification appear to be without the power of fecundity. A whitish dust, or rather seed, is sometimes produced from the flowers; yet this, being sown, has never been known to vegetate in the West Indies; while in the East, canes may be raised from seed.* It is, however, easily propagated by cuttings, and multiplies itself surprisingly. The Torrid Zone is most favourable to its production, but it may be cultivated as high as the fortieth degree of latitude.

* Bruce's Travels.

The following description of the cane is principally derived from Dr. Dutrone's Histoire de la Canne.

It is more or less hardy, according to the situation and soil in which it grows, and its vegetation is more or less rapid, according to each season and its temperature. Dutrone states the period of its arriving at full maturity, to be from twelve to twenty months; but he was unacquainted with the Otaheitan variety, which was introduced into the West Indies about the end of the last and beginning of the present centuries. This is much larger and finer than the Brazil cane, and comes to maturity in about ten months, in the elevated parts of the older settled West India Islands. But in vales, and in the low alluvial soils of the Colonies, where the land has not been much cropped, the plant is oftener from twelve to sixteen months, and even longer, in becoming fully ripe.

The cane contains three sorts of juice, one aqueous, another saccharine, and the third mucous. The relative proportions of these, and the quality of the two last, depend upon a great number of particular circumstances, a knowledge of which is of the greatest importance in regulating the judicious care required for the cultivation of this plant. The cane, as in reeds, and other gramineous plants, has a knotty stalk, and at each knot, or joint, there is a leaf and an inner joint. The stole is distinguished into two parts; the first is formed of several peculiar joints, varying in number from five to seven, which are placed very near to each other, having rows of little points at their surface, which are elements of roots. These joints are called radicles,

because their function appears wholly to consist in sending forth roots. They are divided from each other by a leaf called the radical leaf. The whole of these joints form the first part, or *primitive stole.* As this would not be, in itself, sufficient for a numerous filiation of joints, nature has endowed the cane joints likewise with several rows of points, elements of roots, which develope themselves when requisite, and form, with the joints whence they issue, a secondary stole; they thus form roots, till the joints are sufficiently numerous and strong to put forth and sustain those which are to follow them, and form the stalk. This second part of the stole becomes very strong, and seems to serve, alone, for the filiation of all the remaining joints. The roots issue from the development of the sap vessels, which are disposed in concentric rays, round each point, on the surface of the joint. The sap vessels of the root, cut transversely, exhibit a circular surface of a. cellular tissue, and are covered with a skin, which is first white, and then brown or black. The roots are very slender and almost cylindrical; they are never more than a foot in length; a few short fibres appear at their extremities.

The number of joints of the stalk or cane vary from forty to sixty, sometimes even eighty, in the Brazilian cane; but there are much fewer in that from Otaheite, its joints being much farther apart, some of these being eight or nine inches long, while the finer specimens of those of Brazil are from two to three inches in length. The joints vary very much in their dimensions; they are short or long, large or little, straight or bulging; and several of these differences are sometimes found in the

same cane. The knots of the canes are not simple enlargements, as in the greater part of reeds, and the gramineous family of plants. They are rings, from an eighth to a quarter of an inch wide. Four or five rows of semi-transparent points go round their circumference. A circular semi-transparent line very perceptibly divides the outer from the inner joint. At the upper part of this there is a slight circular hollow, called the neck, which is terminated by the leaf belonging to the joint. The inner joint is entirely subordinate to the outer one, both in its development and growth. It is destined to perform a most important function; in it the juice, after having undergone various modifications, arrives at the state of its essential salt.*
There is on every joint a bud, which encloses the germ of a new cane.

If the intimate structure of the various parts of the cane be minutely examined, its sap and proper or returning vessels will be readily discovered. The sap vessels are abundantly large and very numerous, being more in number than 1500. They are both simple and compound, and when cut transversely, one opening appears in a simple vessel; but if compound, two, three, or even four openings are distinctly seen by the aid of a magnifying glass. The function of the proper vessels is to separate the peculiar juices, proper to the plant, in the leaves, the rind, and the interior of the cane. They are symmetrically arranged, especially in the interior of the inner joint, in hexagonal cavities,

* We denominate, by this term, that portion of the juice which will crystallize.

similar to those of a bee-hive, forming, at equal distances, cells, placed horizontally, one upon the other. At a point somewhat raised on the stalk, each sap vessel divides itself into two parts, one continues the vertical direction, the other becomes horizontal; the latter grows interlaced with the vertical portion, and after having formed a partition of about a sixth of an inch in breadth, they unite themselves into a bundle or *fasciculus*, which pierces the rind, and forms the bud, which incloses the germ of a future generation. The buds always grow alternately on the opposite sides of the joints. The partition formed by the horizontal vessels separates the joints internally, and prevents all communication between them, as far as regards the peculiar function of each.

The vessels which continue in a vertical direction have, through the whole extent of the outer joint, one of their sides convex, and the other concave, till they again become round by the meeting of other vessels; the points of this union are marked by a semi-transparent ring, which forms a line of demarcation between the outer and inner joints. This is the part of the cane where it is weakest, and most apt to break. The space left between the sap vessels, running from one partition to another, is filled by cells, which form the symmetrical disposition of the proper vessels.

The rind of the cane consists of three distinct parts: the rind, (properly so called,) the skin, and the epidermis.

The rind is formed of sap vessels, ranged in a parallel direction, on a compact circular surface.

The skin, which is very thin, is at first white and tender; it then becomes green, then yellow, as the joint approaches to maturity, the period of which is shown by streaks of deep red.

The epidermis is a fine and transparent pellicle, which covers the skin. It is almost always white.

At the upper part of the inner joint the rind divides itself into two parts. The inner part forms the rind of the following joint. The sap vessels of the outer part are joined by several other sap vessels from the interior, with which they rise, supported by a reticulated tissue, and form the leaf, upon which the skin and epidermis of the rind are continued.

All the leaves, except the three first radicals, are divided into two parts by a nodosity. The lower part of the leaf is sometimes more than a foot long; it envelopes the upper joints, folding itself very closely round them. Its inner surface is white, polished, smooth, and shining. Its outer surface is slightly indented, and bears a great number of very minute white thorns.

The upper part is four feet, and sometimes even more in length. After rising out of the ground it gradually recedes from the cane as it grows, and forms with it a proportionate greater angle in approaching to maturity. Its greatest width is two inches, thence tapering to a narrow point.

The nodosity is about half an inch broad; the texture of its skin is softer, thicker, and of a darker colour than the other parts of the leaf. It has, on the inside, a very thin membranous fold, very tightly applied round the body of the cane. A channel for the rain is formed by the upper part of the leaf, and this fold, which

is, at the same time, a barrier against extraneous bodies, and protects the young joints, at the time of their development, from the attack of insects, which might otherwise destroy them. The leaves are placed alternately on the joints, and expand at top in a kind of fan.

The natural history of plants shows the phenomena of the fructification and fecundation of the germ, the laws which this germ follows in its development, the different revolutions which the plant undergoes from its birth to its total decay, and the various accidents of the different periods between these two terms.

To conduct the cultivation of a plant on enlightened and rational principles, it is indispensable that the cultivator should have a thorough knowledge of its natural history.

This will teach him what soil and what climate agree best with the plant. In understanding the most favourable circumstances for its vegetation, he discovers the causes of all the accidents to which it is liable, and is best able to guard against their recurrence, at the same time that he is necessarily conducted to the better knowledge of the nature and the quality of its products.

All the parts of the cane form, develope, grow, and rise, successively, one upon the other, in such a manner, that each particular part is a whole, which appears to pursue its own course, independent of the other. This peculiarity will be more particularly explained as we proceed. We will now trace the development of the plant.

The bud consists of the germ, tightly enclosed within

little leaves. The development of this germ is necessarily governed by the same laws, in every part of the cane in which there is a bud. The radical knots can easily be perceived and examined in their first development, especially upon buds developed on the upper part of a cane. If the head of one be cut off, its buds, then receiving the juices which would have continued to nourish the head, are sometimes sufficiently developed to throw out twenty joints. After having removed the radical leaves, the first cane joint is generally discovered under that of the fifth knot—it is known by the appearance of the bud; if it be without this, it must be reckoned a radical knot, then the following joint will have the bud; but if that, too, be without, which very rarely happens, the bud will certainly be found on the next or seventh knot. It is from the centre of the last radical knot that the germ of the first cane joint springs. This germ encloses the vital principle of the cane, and of the generation of the joints. The first, in forming itself, becomes the matrix of the second,—the second of the third,—and so on, in succession. There is always a degree of difference in the various revolutions of each joint, marked by the time of its generation; so that the joints of the cane may be considered as concentric circles, the centre of which is always occupied by a point, which, expanding into a circle itself, is replaced by a new point; circles which, rising successively one upon the other, enlarge, and arrive, in a given time, at their greatest diameter.

When circumstances are very favourable for vegetation, it often happens that, immediately after the first de-

velopment of the cane joints, which form the secondary stole, the bud of the first of these joints throws out its *radical roots*, and forms a second filiation on the first; *the bud* of *the first* cane joint of this second filiation also sometimes developes, and forms a third: these two last soon become very nearly as forward as the first, and, like it, form canes.

Two distinct operations are carried forward in the cane; the one belongs to the sap vessels, and, reaching to every part, sheds its vivifying power through the whole plant; the other belongs to the system of its proper vessels, and maintains the functions proper and peculiar to each joint.

It would, perhaps, be tedious minutely to follow the plant through all the different shades of its development and growth. Its juice is, of course, variously modified in all its different stages: in its first formation it has all the characteristics of that of unripe mucous fruits; after a while, it very much resembles, both in taste and smell, the juice of sweet apples; by degrees it loses this, and takes the smell and taste peculiar to the cane.

The first joint requires four or five months for its entire growth, and, during this time, fifteen or twenty joints spring from it in succession, and the same progression continues as, by degrees, each joint arrives at the period of its growth, which is ascertained by the decay of its leaf: this is the period of its maturation. When the leaves of the two or three first joints which appear out of the earth have died away, there are then about twelve or fifteen leaves at top, disposed in the form of a fan. If the cane be considered in its natural state,

it has at this period acquired all its growth, and arrived at the usual epoch of its flowering:* if it blooms, the principle of life and generation passes entirely to the development of the parts of fructification; at this period, the joints which spring forth are deprived of their bud; and the sap vessels, with which they were supplied, pass into the leaf; whence it happens that, as the number of these vessels are constantly diminishing, the joints in a similar proportion become longer, and their rind thinner. The last joint, which is called the arrow, is four or five feet long; it is terminated by a panicle of sterile flowers, which are eighteen or twenty inches high. If the period of flowering is delayed by cultivation, then the principle of life passes to the generation of new joints, and this continues till the sap vessels of the stole become woody, and do not afford a passage to the aqueous juices.

* The flowering rarely happens, and never but to a very small proportion of some very few fields. Those canes which flower have very little juice left, which is by no means so sweet as that of the rest.—*Roxburgh.*

On some soils, when the cane is planted early, and a vigorous vegetation is suddenly checked, it is often found to flower.

CHAPTER III.

ON THE INFLUENCE OF SOIL AND CLIMATE IN THE CULTIVATION OF THE CANE.

PLANTS containing mucous juices feel most sensibly the influence of soil and climate. Their juices abound more in saccharine matter in light and loose calcareous soils, than in rich and marshy lands. They require a favourable situation for receiving the influence of solar light and heat, as well as air; most important agents in elaborating and perfecting the saccharine portion of the plants.

Although the cane appears not to differ in kind, there are great modifications in it, as well as in its produce from the same kind of cane: these are marked in the most decided manner, not only in different islands, but in different parts of each. Rumphius, who has considered the cane only as a naturalist, remarks three varieties, and, according to this author, the Chinese distinguish two. The first, they named *Tecsia,* which has a thin rind, the second *Gamsia,* whose rind is thick.

The French introduced plants from the East Indies into their West India Islands, whence they found their

way into some of our colonies. Sir John Laforey, who planted some of these, as well as some canes from Otaheite, in Antigua, soon discovered their superiority over the old canes of the West Indies. He gives the following account of them.

One sort was brought from the Island of Bourbon, reported by the French to be the growth of the Coast of Malabar.

Another sort from the Island of Otaheite.

Another sort from Batavia.

The two former are much alike, both in their appearance and growth; but that of Otaheite is said to make the finest sugar. They are much larger than the Brazilian, the joints of some measuring eight or nine inches long, and six in circumference.* They are ripe enough to grind at the age of ten months;† they appear to stand the dry weather better,‡ and are not so liable to be attacked by that destructive insect, the borer.§ In-

* Their colour, and that of their leaves, also differ from ours, being of a pale green; their leaves broader, their points falling towards the ground as they grow out, instead of being erect like those of our Islands. Their juice also, when expressed, differs from that of our canes, being of a very pale, instead of a deep green colour.—*Sir John Laforey.*

† A few cut for trial above twelve months old, were judged to have lost part of their juice by standing so long.—*Ibid.*

‡ I observed, that after a drought of long continuance, when the leaves of our own canes began to turn brown at their points, these continued their colour throughout.—*Ibid.*

§ A gentleman of Montserrat had some plants given him in the year 1791 by Mr. Pinnel, one of the most considerable planters of Guadaloupe, who told him that, in the preceding year, when an exceeding great drought had prevailed, he had amongst a large field of

deed, these are considered so much superior to the old canes, that their adoption has nearly banished the original Brazilian plant from our Islands.

The Batavian cane is of a deep purple colour on the outside; it is small in circumference, but bunches exceedingly, and vegetates so quickly, that it springs up in one-third of the time that the common cane does.

In new and moist land, such as the colonies of Dutch Guiana, the cane grows to the height of twelve, fifteen, or even twenty feet. In arid calcareous soils, it sometimes does not attain a greater height than six feet, and one of ten feet is considered long.

the Island canes, half an acre of these; that the want of rain, and the ravages of the borer, had damaged the former so much that he could not make any sugar from them, but that the latter had produced him three hogsheads.

In the spring of this year, 1794, a trial was made of the Malabar canes on one of my plantations; 160 bunches, from holes of five feet square, were cut, they produced upwards of 350 lbs. of very good sugar; the juice came into sugar in the teache in much less time than is usually required for that of the other canes, and threw up very little scum. The produce was in the proportion of 3500 lbs. to an acre. The weather had then been so very dry, and the borer so destructive, that I am sure no one part of that plantation would have yielded above half that quantity from the other canes in the space of ground.—*Ibid.*

In April, 1798, two acres and a half of Bourbon-canes, in St. Thomas in the Vale, one of the most exhausted parishes in Jamaica, yielded near eight hogsheads of above sixteen hundred weight each, of clear and strong grained sugar; which gives above 5700 lbs. for the produce of each acre.

A writer from Tobago says, this cane passes wonder, and renders the appearance of the old canes unpleasant. I could not, as a planter, have credited on report, what I have witnessed of it.—*Macpherson's Annals of Commerce*, 1805.

Dutrone mentions five varieties which he classes in rather a fanciful manner. Perhaps these varieties may be merely the effects of different soils and situations, but even if this be the case, his observations are made with so much laborious accuracy and acute comment, that they may be found useful in imparting a thorough knowledge of the cane in all its bearings; we will, therefore give a slight sketch of these varieties. He says, "After the numerous observations I have made upon the changes and modifications which the cane receives, not only from soil, climate, and cultivation, but from the influence of the seasons, from the air, the light, and the sun, from moisture or dryness, I believe I am able to enumerate all the varieties of this plant. I distinguish the cane as hardy and tender, and I again distinguish in these two states, particular gradations." We will not be quite so diffuse as the author in describing these.

The most hardy kind is firm upon its stole, resisting the wind, which never lays or breaks it. It supports, equally well, much moisture or dryness, and goes through its progressions slowly; it rarely begins to decay before eighteen or twenty months. This sort of cane is the best and most rare. The top part has fifteen or sixteen joints, the leaves of which are very long and wide, their colour is of a fine green, the joints of the cane are very large and bulging, and about two or three inches long. They are yellow: sometimes they have a green tint, especially when the land is new. The buds are very large; the number of joints is ordinarily from thirty-five to forty-five. This cane is very little affected by a backward season. Its juice is abundant. The great proportion of mucilage which it contains, renders it difficult of clarifi-

cation. It is rich in sugar of excellent quality, the concentration of which is very easy, especially when the degree of heat does not exceed 230° of Fahrenheit. This cane must never be cut before eighteen or twenty months growth. The cane in the next degree hardy, must be cut at from sixteen to eighteen months. It has generally from thirty to thirty-five joints, not so large as the hardiest cane. Its juice is very abundant, and easy to clarify, yielding the essential salt abundantly. The cane in the third degree hardy, grows on high grounds, and requires abundance of rain: it ought to be cut at fifteen or sixteen months. The top has from ten to thirteen joints, with short straight leaves of a yellowish-green. The cane has from twenty to thirty joints, which are very little bulged, sometimes quite straight; they are only one or two inches in length, their colour is yellow, a backward season has a very sensible influence over it. Its juice is not very abundant, but it is of very good quality, sometimes it has a great deal of mucilage, which renders the clarifying difficult, and impedes the extraction of its essential salt, especially when it is exposed to a great degree of heat; 238° or 239° of Fahrenheit is decidedly too high: when so highly heated, the mucilage is found in the greatest proportion, and is most prejudicial.

The tender plants are divided into good and bad, the former is most general: it grows in the plains. Its constitution is modified, but not changed, by the nature of the soil; much rain still further weakens and renders it bad. Extreme dryness causes it to wither; its maturity is dependent on the season, it being commonly completed at eleven or twelve, but sometimes not until fifteen or six-

teen months. The wind often lays and sometimes breaks it. It is frequently bent and crooked. The top part has twelve or fifteen joints, with leaves two or three feet long, the colour of which is a very delicate green. The cane has twenty or thirty joints, the thickness of which depends on circumstances; they are about three or four inches long, very little bulged, often straight, and sometimes even slightly going in. Their colour is a deep yellow, with streaks of red, which appear as they approach maturity. The juice, which is sometimes very abundant, is easy to clarify. In favourable seasons it is rich in essential salt of good quality: in a backward season, the juice is very poor; it requires a very moderate heat for its granulation. The bad sort of the tender cane grows in humid and marshy lands, it also grows in lands which have been newly put into cultivation. Extreme dryness is favourable to it, as much rain always injures the formation and secretion of its saccharine matter. It is weak on its stole, as the wind always lays, and very often breaks it. Its period of decay is from fifteen to sixteen months. Its top has fifteen or sixteen joints, with long wide leaves of a deep green colour. The cane consists of twenty or thirty joints, four or five inches long, rarely bulging. The colour is a pale yellow, sometimes approaching to green. Its juice is often very abundant, the clarifying is always easy, and after a long drought, the best are rich in essential salt, which is very fine, and easily obtained, if the boiling be well conducted. After abundant rains, particularly in a backward season, the juice is very poor, and contains a greater or less proportion of mucous juice, which has been prevented by these circumstances from forming

into essential salt. The boiling must consequently be managed with the greatest care, to obtain the essential salt. The cane is often badly made and crooked. From all these particulars, it is evident how needful it is, to the successful cultivation of the cane, that its general nature and peculiar functions should be understood, so that we may know how, most judiciously, to direct and assist the action of the various agents of vegetation and maturation. Water being one of the most powerful of these agents in the vegetation of the cane, the cares of the cultivator should be directed towards the best means for supplying it, and for causing the cane to profit, as much as possible, by all that it receives, either in the form of rain, or by irrigation. As a principal means of effecting this, the ground should be very much loosened round the plant, the facilities for which operation necessarily vary according to the nature of the land, and many other circumstances.

Before giving any directions for diminishing or removing these obstacles, it will, however, be better to show, what soil is most favourable to the production of the cane; whence may be induced the remedies required to approximate other soils, as nearly as circumstances permit, to this desirable state.

A mixture of clay and sand, or, what has been called brick-mould, seems to be generally acknowledged as most favourable to the growth of the cane; and, although the effects of rain on this soil are apparently soon over, its surface quickly drying, the inner portion retains a considerable degree of moisture even in the driest weather, and it has the advantage of seldom requiring trenches to be made even in the wettest season.

This soil very much predominates in St. Domingo; in Jamaica it is confined to particular districts, and even in those districts to particular spots.*

Next to this, black mould of several varieties is favourable for the production of the cane. There is a species of this mould in Jamaica, which abounds with limestone and flint on a substratum of soapy marle. Black mould on clay is more common, but it is generally only in a very thin stratum, and the clay is tenacious and retentive of water: this last sort of land, therefore, requires great labour, both in ploughing and trenching, to render it profitable; but properly pulverized and manured, it becomes extremely productive.

The best black mould is found in Barbadoes, Antigua, and some other of the Windward Islands. But the very best soil for the production of sugar of the finest quality, and in the largest proportion, is the ashy loam of St. Christopher's. The alluvial soil of Guiana is most favourable to the vegetation of the cane, but not to the elaboration of its saccharine juice, except in old settled plantations having the benefit of the sea breeze without receiving its spray.

Canes will not flourish on a merely sandy soil: to make them grow there, requires a great expense for manure, as well as frequent rains, or the command of water for irrigation.†

* Plant-canes in this soil have been known in very fine seasons to yield two tons and a half of sugar per acre.—*Edwards's West Indies.*

† There is, however, a peculiar sort of land on the north side of Jamaica, chiefly in the parish of Trelawney, that cannot be passed over unnoticed, not only on account of its scarcity, but its value; few soils producing finer sugar. The land alluded to, is generally of a

When we consider the composition and constitution of soils, and the manner in which land is enriched by manure, or rendered fertile by the different processes of cultivation, we cannot hesitate to assign to this subject an important place in treating of the culture of plants.

5. When land is unproductive, we should inquire into the cause of its sterility, which must necessarily result from some defect in the constitution of the soil. Some lands of apparent good texture, are yet extremely barren. 6 In such cases, the cause can only be ascertained by chemical analysis; then the noxious principle which exists will be easily discovered, and most probably easily destroyed. If any of the salts of iron be found present, they may be decomposed by lime. If any inert vegetable matter be indicated, this can be removed by lime, paring, and burning. If there be a deficiency of vegetable matter, it may be supplied by manure. If there be an excess of silicious sand, a mixture of marle will eminently correct it.

In stiff, heavy soils, chalk and sea-shells are used with great advantage. Low, swampy grounds, besides the assistance of lime, chalk, or sand, according to the nature of the soil, should be well drained, and every facility given for the escape of the stagnant waters, and the overplus of those which collect after storms. The land should be divided by wide ditches into parallelograms or beds, the drains being from ten to a hundred feet apart, according to the degree of moisture of the earth, and

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red colour; the shades of which, however, vary considerably, from a deep chocolate to a rich scarlet; in some places, it approaches to a bright yellow, but it is every where remarkable, when first turned up, for a glossy or shining surface, and if wetted stains the fingers like paint.—*Ibid.*

each of these beds should be slightly raised in the middle, gradually sloping towards the ditches.

Lime is beneficial to almost any soil, particularly new, and especially where the salts of iron are found.*

Where carbonate of lime already exists in the soil, lime and chalk are useless, inasmuch as there is little or no undissolved vegetable matter.†

Marle‡ mixed with sandy clay materially improves the soil. It is understood that the agriculturists of the West India Colonies are now better acquainted with the advantages they possess, and use these valuable substances, wherein some of the Islands abound.§

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* Wood sorrel, coarse tufts of grass, and various sour herbage, indicate the presence of oxide of iron, in Europe.

† Lime should never be applied with animal manures, unless they are too rich, or for the purpose of preventing noxious effluvia. It is injurious when mixed with any common dung, and tends to render the extractive matter insoluble.—*Ure's Dictionary of Chemistry.*

‡ Marle, a mixture of clay and carbonate of lime.

§ Perhaps Bryan Edwards drew their attention to this matter by asking, "Why for instance are not the manures of lime and sea-sand, which abound in these Islands, and have been found so exceedingly beneficial in Great Britain, brought into use? Limestone alone, even without burning, (the expense of which might, perhaps, be an objection,) has been found to answer in cold, heavy, and moist lands; no other trouble being requisite than merely to spread it over the ground, and break it into small pieces by sledge hammers. Of this the quantities are inexhaustible. Marle is another manure of vast and general utility in Great Britain. It enriches the poorest land, opens the stiffest, and sweetens and corrects the most rank. Lands have been raised by the use of this manure from two shillings per acre to a guinea annual rent. Now there is no country under the sun, wherein a soft unctuous marle more abounds than in Jamaica."—*Edwards's West Indies.*

In the present day, however, the Jamaica planter takes advantage of the fortunate circumstance of possessing these substances, and more or less employs them all.

In a loamy soil, (which consists of sand and clay,) lime may be used with advantage.

Lime acts immediately in producing beneficial effects, chalk not so soon, but it is more permanent in the advantages it affords to the soil. In this country about two hundred bushels of lime are found sufficient for each acre, and from fifteen to twenty of two-horse cart loads of chalk per acre.

These are to remedy the defects of soil. Animal and vegetable manures are to renovate worn out lands, by supplying new soluble and gaseous matter, for the nourishment of the plant. This is not a permanent good, and requires to be constantly renewed; as it is found by universal experience, that vegetable and animal substances used as manure, are *consumed* during the process of vegetation.*

The properly manuring of lands is a most important operation in sugar planting; even the best soil requires occasional assistance, and there is much yet to be learnt by agriculturists in the management of this most essential branch of husbandry.

The Chinese appear to understand the matter better than most other people: every animal and vegetable refuse, every thing of disgusting appearance and offensive

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* These can only nourish the plant by affording solid matters capable of being dissolved by water, or gaseous substances capable of being absorbed by the fluids in the leaves of vegetables.

The great object in the application of manure should be to make it afford as much soluble matter as possible to the roots of the plant; and that in a slow and gradual manner, so that it may be entirely consumed in forming its sap and organised parts.—*Ure's Dictionary of Chemistry, Art. Manure.*

effluvia, they carefully collect and use as beneficial agents in vegetation, thus converting the loathsome and revolting, into the wholesome and inviting.

The sugar planter might advantageously follow the example of the Chinese in this respect. Great improvidence and waste are too often practised, and the land, as a necessary consequence, suffers.

The cane trash, which is used as fuel, would make excellent manure, and therefore it is of importance to be as economical in fuel as possible.*

The lands are at present imperfectly manured, and yet very frequently cattle are kept for the sole purpose of providing manure. Recourse also is obliged to be had to supplies from England, and much compost is sent out from this country to the Colonies.

The manure which is used, is generally a compost made of

1st. The coal and vegetable ashes drawn from the fires of the boiling and still-houses.

2d. Feculences discharged from the still-house, mixed up with rubbish of buildings, &c. &c.

3d. Refuse or field trash, that is, the decayed leaves and stems of the canes.

4th. Dung obtained from the horse and mule stables, and from fixed and moveable pens.

5th. Good mould collected from ravines, or gulleys, and other waste places.

The first is supposed to be a manure in itself for cold and stiff clays, and it is the custom in some places in

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* Cane trash . . . . . . which we reckon the richest manure we have, when properly prepared.—*Sir John Laforey.*

which this soil is found, to carry the ashes out in autumn, and place them, unmixed in large heaps. When the land is holed, a quantity of about fifteen or twenty pounds is put into each hole, and mixed with the mould, at the time the plants are put into the ground. But ashes thus applied cannot be very beneficial, as they neither afford soluble matter for the nourishment of the plant, nor correct any defects of the soil. In very wet lands, ashes may prove advantageous, in absorbing the superfluous moisture, but then they should be spread outside, not be mixed with the earth.

The compost is used in the same manner as ashes, not being carried to the land till just before it is required. The moveable pens are, however, the chief dependence of the Jamaica planter; in the Windward Islands manuring is more carefully applied. From all cares on this subject, the colonists of Dutch Guiana are at present exempt, as their soil can be efficiently manured, as well as irrigated, by admitting the rivers to overflow the lands, the deposit which these leave being very fertilising. But as the process is attended by the production of unhealthy miasmata, it would perhaps be to their advantage to renew the fertility of their front lands by manure, rather than by a process so unhealthy; and we have reason to believe that this opinion is every day gaining ground.

A moveable pen is made of light railings tied together, and to posts fixed firmly in the ground, enclosing a piece of ground proportionate to the number of cattle to be turned into it; at the end of a week it is shifted, by leaving one side standing, and moving the other three sides on the opposite face of the remaining side, thus enclosing

a second piece: into this fresh enclosure the cattle are turned for another week. In this manner it is moved every week till the planter gradually goes through his whole estate, and follows it up by turning up the soil for tillage. This is considered a very advantageous practice; indeed, some overseers entirely trust to it, and give the ground no other dressing.* But it is by no means sufficient on plantations that have been much worn and exhausted by cultivation. In Barbadoes the practice is to tether cattle to stakes driven into the ground. The spot is covered with good mould, and then well littered with dry and green vegetable matter, which, with the animal manure from the cattle, make a compost heap sufficient for a certain space of ground. When this is completed the stakes are withdrawn, and placed in another part of the field, in which the same process is renewed. By this system much animal and vegetable manure is accumulated on the fields to be manured, but as much labour is required to bring mould and dry and green vegetable matter to form successive layers, some planters adopt the Jamaica plan of moveable pens already described.

The common allowance of manure where this branch of husbandry is best understood, is a cubic foot to each cane hole, but it is obvious that no precise rule can be laid down as to the most beneficial quantity to be used. This must depend upon the nature of the soil,

* In hilly and mountainous districts, it is considered impracticable to manure in any other manner. Then the pens are made in a somewhat more durable manner, and the cattle remain in them, till they have furnished manure for a greater portion of land than that in which they are enclosed.

and upon the quality of the manure. Much less of this, properly prepared, and in a fit state for use, will, of course be required, than of that which has the fertilising principle in an inferior degree.

In employing manure, we must endeavour to procure for the canes, not the greatest possible, but the most profitable vegetation, for a too luxuriant growth is prejudicial to the elaboration of the saccharine juice. If too little be used, it is unavailing and lost. The canes are then soon scorched up, the sun causing the rapid exhalation of those few aqueous parts, which a too weak vegetation has only had the power of forming, and the saccharine juice becomes closely united to an empyreumatic oil, which entirely vitiates it.

It is requisite to allow the lands occasionally to lie fallow. This is found to restore them as much as the usual quantity of manure. But the weeds must by no means be suffered to gain dominion over them while in this state, since these exhaust the land as much as those plants which are useful.*

Much difference of opinion has prevailed as to the

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* I have made a number of experiments upon the advantage of allowing the ground to lie fallow. The successful results of all these have confirmed me in the adoption of this method. Among others, I made trial upon two pieces of ground of the same nature and quality, the one situated in the highest part of my plantation, the other on the sea coast. These two pieces received two ploughings during the six months they were fallow; and, planting them afterwards, without any manure, I obtained very superior crops; but the canes of the sea coast were better than the others. This observation induced me to put into each hole of a neighbouring piece of ground some sea-water at the time of planting, and the experiment succeeded admirably.— *De L'Exploitation des Sucreries.*

state in which manure ought to be ploughed into the ground; whether recent, or when it has gone through the process of fermentation. Those who have considered the subject chemically, entertain no doubts; and the great authority of Sir H. Davy seems to be conclusive, that recent manure is most valuable. As soon as dung begins to decompose, it throws off its volatile parts, which are the most valuable and efficient. Dung, which has fermented to a mere soft cohesive mass, has generally lost from one-third to one-half of its most useful constituent elements.* Perhaps, however, it would be adviseable to allow a slight degree of fermentation to take place before it is exposed, in divided quantities, to the scorching heat of the tropical sun. The Guadaloupe planter whom we have just quoted, strongly deprecates the pernicious practice, (as he terms it,) of using recent manure in hot climates. The Barbadoes system of making manure permits a certain degree of fermentation to take place previous to its application to the soil, whilst it is covered with mould until it be so applied; thus preventing the action of air upon it to a certain extent.

* To prevent manures from decomposing, they should be preserved dry, defended from the contact of the air, and kept as cool as possible.

All green, *succulent plants*, contain saccharine or mucilaginous matter, with woody fibre, and readily ferment. They cannot therefore, if intended for manure, be used too soon after their death.

If dung cannot be immediately applied to crops, the destructive fermentation of it should be prevented very carefully.

The surface should be defended, as much as possible, from the oxygen of the atmosphere; a compact marle, or a tenacious clay, offers the best protection against the air; and before the dung is covered over, or, as it were sealed up, it should be dried as much as possible.—*Ure's Dictionary of Chemistry, Art. Manure.*

CHAPTER IV.

ON THE CULTURE OF THE SUGAR CANE.

The canes are distinguished into plants, and suckers springing from the stoles of the plants; these suckers are commonly called rattoons.

The cane plant is produced by the development of the buds of a slip put into the earth, and this slip generally comprehends the top part, stripped of its leaves, and the two or three upper joints of the cane. Holes should be made from fifteen to eighteen inches square,* and about eight, ten, or even twelve inches deep. These holes are made about two feet apart from each other, in rows which are three feet distance asunder; but this depends much upon the soil, and the practice is not uniform throughout the Islands. The rows should be marked by a line, and the ground

* The sizes of the squares differ very much in different Islands, being frequently larger than these dimensions; and in new lands, as in Trinidad, the cane is sometimes planted without holing the land, as in the old Islands. In Guiana, again, the cane is planted in trenches, to allow the excess of moisture to run off by the surface drains.

should be divided into pieces of about seventy feet broad, leaving a space between each of twenty feet broad, for the convenience of carting. The hole is banked up round its margin, with the earth thrown up by the hoe, and manure is put into it. Two or more cuttings* are then laid longitudinally in each hole, and, at first, these are covered with earth to the depth of only one or two inches. The plant is thus placed in the most favourable state for receiving and retaining the water acquired either from rain or irrigation;† the loose state of the earth allows the roots to penetrate and spread with facility, while these numerous and spreading roots supply in very great abundance the moisture necessary for the vegetation of the plants.

Edwards‡ recommends the use of the plough in making the holes, or *holing*, and speaks of its great advantage from his own practical knowledge; since he wrote, it has been extensively adopted.§ By ploughing, and then returning the plough back along the furrow, the earth is alternately thrown to the right and to the left, forming a trench seven inches deep, about two

* Miller recommends only one or two being put in, and if both succeed, to draw one out. "Thus," he says, "blights would be prevented, the quantity of sugar would be full as great, and require much less fuel to boil it."

† The superiority of the sugar in St. Domingo is supposed to have arisen from the facility of irrigating the lands. In Guiana, this, likewise, can be practised; but in the greater part of the colonies, the only moisture that the plants receive is from rain.

‡ Edwards's History of the West Indies, Vol. ii. p. 248.

§ The ploughshare must be rather wider than the ordinary one; there is no other difference required.

feet and a half wide at top, and one foot wide at bottom. There is a space of eighteen or twenty inches left between each trench, on which *the mould being thrown by the share*, the banks are properly formed, and the *holing* is now complete in lands which do not require intermediate banks to retain the rain water. In such lands banks are made with the hoe, after this mode of ploughing has been finished.*

In about a fortnight after planting, the young sprouts appear a few inches above the earth. Some of the earth which is heaped up round the hole, is now put in, and as the plant grows, this work is continued gradually for about four or five months; by that time the holes should be quite filled up. In the mean time, hoeing† must be carefully attended to, all weeds being diligently

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* Holing may certainly be despatched with much greater facility by the plough than by the hoe; and the relief, which, in stiff and dry soils, is thus given to the negroes, exceeds all estimation, in the mind of a humane and provident owner. At a plantation of my own, the greatest part of the land which is annually planted, is neatly and sufficiently laid into cane holes, by the labour of one able man, three boys, and eight oxen, with the common single-wheeled plough. It is reckoned a tolerable day's work for forty negroes to hole an acre in the course of a day.—*Edwards's West Indies.*

As the plough has been so generally introduced into West India agriculture, where practicable, (for in some situations it cannot be used,) we think it may be interesting to add, in an Appendix, some observations on the use of the plough, drawn up for the information of the Agricultural Society of Antigua, by one of its most distinguished members, and kindly communicated in manuscript to the author of this work by Major Moody.

† If the horse hoe is used, the rows must not be less than five feet apart, and the distance between the holes not less than two feet and a half.

removed. This is of great importance to the healthy growth of the plants, and should never be neglected. The off-shoots which spring up from the stole, should likewise be taken off, as they draw off the nourishment from the plants, and seldom make effective canes themselves. The time for cutting varies, as we have already explained, not only with the soil and season, but with the different varieties of the cane, some coming to maturity much quicker than others.

When the skin of the cane becomes dry, smooth, and brittle; when it is heavy; the pith gray, approaching to brown; the juice sweet and glutinous; then it may be considered in perfection.* It is of great advantage that the canes should be cut in the dry season, as they then always produce better sugar than those cut in the rainy season, when they are more replete with aqueous juice, and require more fuel in evaporating it.

In small plantations, where there are only a few negroes, the planting is carried on when it is most convenient, and not when most advantageous; and the sugar is made through all the seasons. Colonel Martin strongly deprecates this practice, when it can be avoided, considering it the greatest error in the system of planting, to make sugar, or to plant canes, in improper seasons.† In Guiana, from peculiar local circumstances

* When the cane is ripe, it may be ascertained by making an incision with a sharp knife, across the cane, and observing the internal grain; if it prove soft and moist, like a turnip, or such soft, edible roots, it is not yet fit for cutting; but if it cuts dry, and white particles appear, the cane is ripe and fit to cut.—*A Treatise on the Cultivation of the Sugar Cane, &c. By W. Fitzmaurice.*

† He observes, "A plantation ought to be considered as a well

connected with the seasons and the climate, the planters are often obliged to cut their canes when the weather is not favourable for making good sugar.

Between August and November is generally considered the best time for planting. The young canes, nourished by the rain, then become sufficiently luxuriant to shade the ground before the dry weather sets in; thus keeping the roots cool and the earth around them moist. But the season for planting depending so much on local peculiarities in different countries, no general rules can be given on this head.

Cazaud, who appears to have had much practical experience, recommends May and June as the most advantageous period for planting. After employing the first six months of the year in the business of the crop, he then plants the land, from which the canes were cut in January; he only plants a sixth of his land every year, leaving the rest for rattoons. He cuts his whole plantation every year, and thus both his plant canes and rattoons are cut at eleven months' growth. The reason given for pursuing this course, is chiefly the advantage of planting the canes in the season best fitted to accelerate and preserve them; as, in the Windward Islands, the weather is commonly dry from the 15th of February

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constructed machine, compounded of various wheels, turning different ways, yet all contributing to the great end proposed; but if any one part runs too fast or too slow in proportion to the rest, the main purpose is defeated. It is in vain to plead in excuse the want of hands or cattle, because these wants must be either supplied, or the planter must contract his views, and proportion them to his ability; for the attempt to do more than can be attained, will lead into perpetual disorders, and terminate in poverty."—*Edwards's West Indies.*

to the 15th of May, from thence the rain is moderate, till August, encreasing till November, then decreasing till February, and thus the progression of the rain keeps pace with that of the cane, when planted in May. The maturity of the cane, as it regards its essential salt, does not, as he asserts, depend upon its age, but upon the season, canes being, (whatever their age,) as ripe in February, March, and April, as the nature of the soil ever allows them to be.

Under such local circumstances, therefore, it would be decidedly wrong to plant in and after November, as the plants then not only lose the benefit of the autumnal rains, but it often happens, that the dry weather at the beginning of the ensuing year retards their vegetation. When invigorated afterwards, by the May rains, they sprout, both at the roots and joints, so that at the time for cutting, there are nothing but unripe suckers, or off-shoots, instead of sugar canes.

Some adopt another plan:—they plant in August and September, and proceed as usual till January, when they cut the young plants close to the ground with knives, and spread the remainder of the mould over the roots, which soon afterwards send forth a number of vigorous luxuriant shoots all of an equal growth. It is said, that by these means the canes are not too rank in the stormy months, while they come to perfection in good time in the succeeding spring.*

The rattoons are the development of the buds

* This system has been advantageously followed, but it requires much knowledge of the seasons, and the degree of fertility of the soil where it may be applied.

which form the secondary stole of a plant that has been cut. These are called first, second, third, &c. according to the age of the root from which they spring; they are found annually to diminish in length of joint and circumference; the first being larger than the second, the second than the third, and so on in a deteriorating progression. The roots of these buds, being fewer than in the original plant, and nearer to the surface of the earth, supply less water for the rattoons, and the ground about them cannot, of necessity, be so effectually loosened and manured, as when the cane is fresh planted and the roots are deeper in the soil. These unfavourable circumstances attendant on the vegetation of the rattoons, limit their number, and retard the vigour of their growth: when, however, having overcome these disadvantages, they reach the growth of plants, receiving the benefit of the air, and solar light and heat; though they do no make so handsome an appearance as the original plant, they yield much richer juice and produce finer sugar.

It is found, from observation and experience, that the juice from the rattoons is much easier clarified, and its essential salt requires less care in concentration, than that of the plant cane, the sugar obtained from which is also of an inferior quality.

On some soils, it is found much better to depend chiefly on rattoon canes, and perhaps it would be more advantageous in every case. The general practice is, to plant a certain proportion of the cane lands, (commonly one-third in the old Colonies,) in annual succession. This, of course, imposes great toil on the negroes; from which they are very much relieved when the

planter trusts to rattoons for his sugar; instead of the excessive labour of holing and planting anew, the stoles are allowed to continue in the ground, and as they become thin and impoverished, the vacant spaces are supplied with fresh plants. But if this method is adopted, great care must be taken to assist the development of the buds by judicious treatment. The earth round the stoles should be loosened, and cleared from weeds; and in the older settled Colonies, as soon as the ground has been refreshed by rain, the stoles should have manure placed round them, which being covered with cane trash, to prevent its virtues being dried up by the sun, is found, at the end of three or four months, to be soaked into and incorporated with the mould. At this period, the rattoons should again be well dressed, after which, very little care is requisite, until the canes are fit for cutting.*

By these means, the produce of sugar per acre, if not, apparently, equal to that from the plant canes in newer soils, yields, perhaps, in the long run, quite as much profit to the owner, if the relative proportion of the labour and expense attending the two methods be taken into consideration.

As soon as the canes are cut, the land which is intended for rattoons requires the attention of the cultivator. If the rainy season be near at hand, all the field-

* Colonel Martin of Antigua advises, as soon as the canes are carried to the mill, to cut off by a sharp hoe, all the heads of the cane stoles, *three inches below the surface of the soil*, and then fill up the hole with fine mould; by which means, all the sprouts rising from below, will derive more nutriment, and grow more equally and vigorously than otherwise.

trash, consisting of decayed leaves, should be laid with other manure about the roots of the plants, the earth being well loosened and cleared of all weeds, either by the plough or hoe. The field-trash is sometimes burnt, but this cannot be recommended; the earth all round, and even under the roots, should be well loosened and the field-trash put in, then the earth over it. There is also another method practised; the decayed leaves are left for some months on the ground, and when they are half decomposed they are buried round the roots of the plants as before.*

If the soil be favourable to the vegetation of the canes, and they are originally planted at proper distances from each other, and the land is carefully managed, the same plantation in the new Colonies, or in rich vales in the old ones, may continue above twenty years without replanting, and continue good crops the whole of the time;† in the common method of planting, the lands are sometimes replanted every six or seven years, but those which are poor are only continued for two or three years.‡

Canes should be planted at shorter distances in land that has been cultivated for a long time than in new land. On high grounds and in the mountains the cane requires close planting, as it is, in such situations, always fully exposed to the air and sun; and in general

* The author of "L'Exploitation des Sucreries" gives a table of the relative advantages of plants and rattoons. The result is: in favour of the rattoons three-fifths less manure, two-thirds less labour employed, and one-fifth less risk. In favour of the plants one-third more sugar.

† In some parts of the West Indies they have been found thirty years old.—*Fitzmaurice.*

‡ Miller's Gardener's Dictionary.

the distances must be regulated by the strength, newness and moisture of the soil, and by the situation unfavourable or favourable to the free access of the air and sun. If the quality of the soil be more favourable to vegetation than to the formation of saccharine matter, it is better there should be some distance between the plants, that they may receive the full benefit to be derived from the unimpeded action of the air and sun, and the stoles will be certain to put forth suckers sufficient to cover the soil.

When vegetation appears too active, it is then adviseable to take off the decayed leaves from the cane, that the plant may receive the unintercepted rays of the sun, otherwise its juices will be poor and aqueous. This is called trashing the cane, and it requires great judgment to know when to have recourse to it. In dry soils or seasons, it would injure, instead of assisting the juice, which would become still more dried up and vitiated by the loss of those leaves, which partially shelter the plant from the too scorching influence of the sun. Care should likewise be taken not to remove the leaves too soon, when the plant would be injured by the separation.

The art of the cultivator consists then in knowing how, properly, to modify, according to circumstances, the influence of the sun and air, so as to render them most advantageous to vegetation and the formation of saccharine matter—in judiciously apportioning the distances of the plants, according to the nature and situation of the soil—in making choice of the most favourable time for planting and cutting—in carefully removing every thing unfavourable to the growth of the plants—

and, above all, in preparing the land by manure, and a proper admixture of earths, that it may receive the most favourable disposition for the vegetation of the plants.

But, however careful and watchful the cultivator may be, there are accidents beyond his controul which occur, independent of soil, weather, or judicious management. The sugar cane is subject to a disease which no foresight can obviate, and which hitherto has baffled human ingenuity in discovering a remedy.

This calamity is called the *blast*. It is the aphis of Linnæus; it is distinguished into two kinds, the black and the yellow.* It consists of myriads of little insects invisible to the naked eye, which feed upon the juice of the cane, in search of which they wound, and consequently destroy the vessels. Hence, the circulation being injured, the growth of the plant is checked, until it withers or dies, in proportion to the degree of the ravages committed.†

In some of the Windward Islands a kind of grub, called the borer, in very dry weather, commits depredations on the cane. This insect was found fatally

* When these appear, all the decayed leaves, in which they harbour, should be carefully removed from the cane-pieces and burnt, while the ground round the roots should be well loosened; if this does not succeed in chasing them away, the roots of the plants should be watered with a decoction of manure in sea-water. This I have invariably found successful.—*L'Exploitation de Sucreries.*

It is said that the blast never attacks those plantations where Colonies have been introduced of the little animal called the carnivorous ant, the formica omnivora of Linnæus, and the raffles ant of Jamaica. —*Rees's Cyclopedia.*

† In Tobago they have another destructive insect, called the ju[illegible]y.—*Edwards's West Indies.*

destructive in Guadaloupe in the year 1785 and 1786. The Otaheite plant is found to be less liable to this casualty than the old canes.*

The Rev. Lansdown Guilding, of the Island of St. Vincents, in a paper communicated by him to the Society for the Encouragement of Arts, Manufactures, and Commerce, for which he obtained their gold Ceres medal, and which is inserted in the 46th volume of the Transactions of that Society, has given the result of his researches and experience in regard to these destructive animals.

"The object of the planter," he says, "should be to prevent the insects from depositing their eggs in the plants, rather than kill those which have already begun their operations.

"From long-continued experiments, I have at last discovered that they may be almost entirely expelled from any quarter in which the canes are carefully stripped of the dry and useless leaves, under which, as they become loose, the female borer deposits her eggs.

"It is well known that the vaginating leaves of the cane hold, for a long period, the water which has been collected in them during rains, from which, in dry weather, the plant may doubtless derive nourishment. In the drier Islands the planter will probably object to the only plan which seems capable of lessening the number of his foes, under the idea that he will expose his plants too much to the merciless rays of the sun. I do not by any means recommend that a single living leaf should be

* The author of "L'Exploitation de Sucreries" recommends introducing a pinch of quick lime in the heart of the stalk of the young cane. He found this a very successful practice.

taken off; and a very slight examination will convince him, that those which have begun to wither are incapable of holding water for the refreshment of the cane.

"The borers are observed to be much more fatal to plant than to rattoon canes.

"A single cane will sometimes nourish several of the borer worms which perforate every joint, when the pithy centre, becoming discoloured and sour, not only yields nothing at the mill, but communicates a dark colour and bad quality to the syrup of the sounder plants."

Many writers whom we have consulted, speak of the devastations committed on the canes by insects as being a very serious evil; but the practical planters, whose opinions we have obtained on the subject, do not seem to consider them as such formidable destroyers.

The rats commit some ravages, and war is constantly waged against them. Should they become too numerous for the rat-catcher, then poison must be resorted to, which will very soon entirely exterminate them.*

Ants are always very numerous, but they in general are more annoying than destructive.

Some years ago white ants† appeared in such incal-

* Burning the decayed leaves on the field is a good method for getting rid of vermin, beginning at each corner and gradually approaching the middle, where a heap of the trash is purposely placed; there the vermin and insects find refuge, and fire being set to it, they are all destroyed.

† Should any white ants be observed in the ground under preparation for planting, or should they make their appearance after the canes have begun to vegetate, the most effectual mode of destroying them will be by poison. Take a small quantity of arsenic, and mix it up with a few ounces of burned and pulverised ship bread, oatmeal, flour, or ripe plantain, moistened with molasses. Place the size of a

culable numbers in Martinique, that the culture of the sugar cane was menaced with total destruction; neither wind nor rain stopped their ravages, when, happily, a hurricane caused them suddenly to disappear entirely.

With every thing most favourable to vegetation, it still often happens, that all the plants do not take root, and sometimes, when circumstances have been adverse to their germinating, there are a great many which do not succeed. It is in consequence necessary to go over the plantation once, twice, or thrice, according to the season, and replace those which have failed. It is recommended therefore that there should be a good nursery established on a piece of rich ground, which should be carefully tended, that there may always be a supply of good plants to transplant, as they may be wanted.

When the canes are ripe and ready to be cut, care must be taken that this task is properly performed. They should be cut as close to the stole as possible, which will give new vigour to the rattoons that are to spring from the old root, while the juice from these lower joints is the richest the cane contains. It may perhaps be sufficient to cut off only one joint of the cane, with the cane top, from those canes which grow on

turkey's egg of this compound on a flat board covered with a wooden bowl, and put several of these in different parts of the plantation. The ants will soon take possession of these wooden vessels, and the poison will have a general effect, for those ants that die being always eaten by the others, the whole estate will be effectually cleared of white ants. Rats can likewise be destroyed by similar means, as when once the poison is taken, it is as effectual as if the animals were destroyed, for vermin of every kind will afterwards shun the plantation.—*Fitzmaurice.*

very dry soils; but, otherwise, two should be cut, for if they be not sufficiently matured, their juice will only injure the sugar instead of augmenting its quantity.

Those canes which are rat-eaten, or otherwise damaged, must be sorted from the rest, and not on any account be sent to the mill, as they would vitiate the juice.

Particular attention must be paid that the supply and demand are made equal. If there be too many canes cut beyond the power of the mill to grind, they will ferment and spoil; and if the mill have to wait for them, the whole work must be stopped, and much valuable time will be lost.

The canes being cut are tied into bundles for the convenience of taking them to the mill. On the mountains they are carried by mules. In some parts the bundles are rolled down the steep places, or passed down wooden spouts. In the plains they are conveyed in small carts, drawn by oxen or mules, to enclosures near the mills; and in Guiana, in flat-bottomed boats or punts, through navigable trenches which intersect the plantations for this purpose.

CHAPTER V.

ON THE VEGETABLE ECONOMY OF THE CANE.

The organization of the cane shows that it absorbs much water in its vegetation, and in the elaboration of its juices. The stole is provided with a very great number of roots. The sap vessels, of which the stalk is formed, are more than fifteen hundred, and these are almost all compound. The plant flourishes best in a moist soil, and experience clearly shows, that it vegetates much more vigorously when it receives abundance of rain, or has the advantage of irrigation. When the bud of a cane joint is put into the earth, the water penetrates and swells it, the little leaves which cover it then develope themselves, and the radical joints lengthen, and shoot forth roots. The three parts which form the primitive stole, are active in the development of the plantule; to which office, alone, this stole appears destined. The cane joints of the plantule shoot forth roots and leaves, which, with these joints, form the secondary stole, serving for the entire growth of the plant. The bud being endowed with all the conditions neces-

sary to the development of the germ it encloses, appears to receive no assistance from the joint whence it originally springs.* The combined action of the roots, sap vessels, and leaves, effect the development of the plant. The action of the leaves, rind, and proper vessels, forms the medullary substance of the cane joints; from this results the conversion of the purely aqueous juices, (supplied by the roots and sap vessels,) into the juices peculiar to the plant; the various modifications of which will be traced and explained.

Observation has shown, that leaves are particular organs destined to fulfil the most important functions in vegetable economy. The divisions and ramifications of their sap vessels multiply almost infinitely. The water, which these vessels contain, after going through all their ramifications, is brought to the most favourable condition for combining itself to the different principles, drawn by the leaves from air and light. Water, either pure or decomposed, assists to form juices, which pass from the leaf into the system of the proper vessels, where they receive the highest degree of elaboration.

These juices have colour, smell, and taste, and they always take that peculiar character in their qualities which they derive from the organization proper to each plant.

We have seen that the leaf is the part of the cane which is first formed, and that it appears at the period

* I have put buds in the ground, having nothing attached to them but a small piece of the rind; they developed well, and produced canes.—*Dutrone.*

of the development of the joint whence it springs: this clearly indicates that its functions are essential to the development of that joint; and this is further proved by experience; for if the leaf just appearing is cut, not only the joint whence it springs does not develope itself, but even the whole cane perishes. If what we have said of the leaf in Chap. II. be called to mind, it will be seen that it possesses the most favourable adaptation for receiving the action of air, solar light and heat, and the electric influences of the atmosphere, all most powerful agents in vegetation. In the leaf, the aqueous juice receives the first impulse for its conversion into the crude mucous state.

At the period of the formation of the cane joint, all its parts are begun, by the action which vivifies the plant; but after this period, it seems to continue all its progressions from its own resources, and to convert the mucous matter, after various modifications, into the essential salt. The sap, which the leaves receive from the sap vessels of the stalk, and the water which it absorbs, combined with the principles furnished by air and light, form, during the development of the joint, a mucous juice, which, after having received its first modification, descends to the lower part of the leaf, passes into the rind and the medullary system of the inner joint, where another modification takes place. The parts of the cane joint becoming stronger as it grows, give to the juices which they elaborate, a new modification, the degrees of which are marked by the proportion and quantity of glutinous matter, which is the base of the smell, taste, and colour of the pure

mucous body; this, in its new state, is sweet, and has the perfume of a ripe apple.

The whole function of the joint, after its growth, seems to be the elaboration of the mucous body. This process is marked by various degrees, the sweet taste and smell resembling apples, becoming fainter as the saccharine taste and balsamic smell peculiar to the cane, gain the predominance. This maturation of the mucous body first brings it to the saccharine state, whence it passes into maturity under the influence of the air, solar light and heat, which the cane joint receives the more freely as its leaf is at this period withered; it loses its colouring part, and arrives at its final state of the essential salt. Such is the progress which nature follows in the formation of the mucous body, and in its conversion, from its first crude state, to its sweet and saccharine qualities, and finally into its essential salt.

The sap of plants is continually renewed by the water which the roots draw from the earth, and convey to the sap vessels, whence it is distributed to the various organs of the plant, for the exercise of their functions. After what has been said of the structure of the roots, and of the number and caliber of the sap vessels of the cane, it may easily be imagined that this plant absorbs a great quantity of water, and consumes it most abundantly, both in its vegetation and in the formation of its juices. We shall distinguish these into sap juice, mucilaginous juice, and mucous juice. The water, in the system of the sap vessels, is not perfectly pure; it holds in solution a matter which forms with it the sap juice. This is always very considerable, especially after abundant rains. By squeezing the cane, the sap

juice flows to the extremity of its vessels, and can easily be collected in a spoon. It is perfectly clear and limpid, and appears as pure as distilled water. But though it has neither colour, smell, nor taste, if it be kept for several days in a phial, it undergoes a change, and a fibrous matter is perceived, which injures its transparency, and then slowly deposits. This matter appears to be pure mucus, which, combined with water, forms the sap juice of the cane.

Mucus appears to be the alimentary substance of the vegetable kingdom, since it is found to exist in all plants. It is formed in the system of sap vessels, and it there receives its first degree of elaboration; it not only serves to nourish the plant, but is found to be the base of all its products. United to a quantity of water, it forms sap. When very concentrated, it takes a solid consistence, still continuing perfectly transparent: this is called gum. Entirely deprived of water, it assumes the form of an extremely fine white powder, known under the name of *amidine*. Pure mucus has neither colour, smell, nor perceptible taste. When it is diluted with a sufficient quantity of water, its presence is alone indicated by its decomposition into an acid and a fibrous matter. This latter forms a sort of membrane, which is not soluble either in water, alcohol, or acids, and which appears to have all the character of gluten. If the pure mucus gives, in its spontaneous decomposition, an acid and a glutinous matter, we can readily understand that these two prinoiples may be easily separated by the action of some particular organ of the plant, and that thus separated, they can unite themselves to other principles, by which they are modified in their removal from their

primitive state. It may also be easily apprehended, that these two principles remaining united, can be modified without their combination being broken, and thence arise all the modifications of this mucus, known under the names of mucilage; of farinaceous, acid, sweet or saccharine mucus; and of sugar.

We have already designated, under the name of crude mucous juice, the first modification which the pure mucus receives in the cane joint. This juice, expressed and left to decompose, always yields an acid and abundant mouldiness. In the modification of the second degree, which we term sweet mucous juice, the glutinous substance receives, in a greater proportion, the principles of colour, taste, and smell. The spontaneous decomposition of this juice is, according to circumstances, either acetous or spirituous. In the first place, it gives an acid, a glutinous substance, and a matter having a colouring property; in the second place, it disengages carbonic acid gas, and forms alcohol, which remains united to the water, and to the sweet mucous juice: this, together, forms a liquor extremely similar to cider. In the third modification of the mucus, the colouring part of the sweet mucous juice assumes a resinous character, and changes its smell into that balsamic one peculiar to the cane. Its merely sweet taste is changed, also, into a sweet saccharine taste. This juice, in its new state, very much resembles honey; we distinguish it as saccharine mucous juice. Its decomposition is like that of the sweet mucous juice. In the last modification, the saccharine mucous juice is entirely deprived of its yellow colour and balsamic smell, while its saccharine taste is much more developed. This last

state is that which constitutes the essential salt of the cane. It is enclosed in cells, which form the medullary substance of the joint; it appears beautifully clear. As each cell is absolutely isolated, and as there is no communication between them, this juice only escapes when it is pressed out by the mills; it can never flow out of the cane, either in the form of syrup or concretion. If we pay attention to the last joint of the cane, which encloses the essential salt, we shall find that it is followed by about twenty joints, which form the cane top: that the mucus in each of these joints is, in a particular degree of elaboration, marked by eight or ten days' difference; that in each of these degrees, it takes at least eight or ten different shades. We shall thus have a slight idea of the number of modifications which the mucus must undergo, before it arrives at the state of essential salt.

The mucilage,* which now remains to be considered, is elaborated in the system of the proper vessels. The glutinous matter of the sap, conveyed by it to the proper vessels of the leaves and rind, afford a base to the principles which these organs draw from air, light, and water, and which give to the mucilage its colour, smell, taste, and solubility. Its solubility in water, as well as in alcohol, have caused it to be considered as the combination of a salt with an oil; several facts, strengthened by experience, prove, however, that its base is a glutinous matter. The rind is, in great part, indebted

* *Suc Savonneux-extractif.* We have expressed this term by the word *mucilage*, as being best calculated to convey its meaning to the general reader; *extractive matter* would, perhaps, be most correct.

to this mucilage for its colour; it can be easily removed by water, but there is a resinous matter also, which assists in the colouring, and which is only soluble in alcohol.

Although the medullary substance appears extremely white, it nevertheless contains a small portion of this mucilage, which, when dissolved in boiling water, slightly tinges it with yellow. Acids seem to have no effect upon this matter, except to fix it more intimately to the solid parts of the cane. Alkalies disengage it, in proportion to their causticity, when combined with a great degree of heat.

CHAPTER VI.

ON THE EXPRESSED JUICE OF THE SUGAR CANE.

We have now traced the progress of the juices, elaborated by the organs of the cane, and briefly investigated their nature.

After this inquiry, it may easily be supposed, that these different juices will vary in their proportions, according to the circumstances of the season, soil, temperature, and the quality of the cane. It is essential that this should be well understood, in order to arrive at a correct and intimate knowledge of the quality of the juice, when expressed from the cane.

When the canes or rattoons are ripe, they are cut, and carried to the mill in bundles, and there submitted to its action. They are compressed twice betwen the rollers, by which means they are squeezed perfectly dry. In this process, the juice carries with it some of the bruised cane, and the whole forms an homogeneous product, which is here denominated the *expressed juice* of the cane, to distinguish it from the juice after clarifying and concentrating.

The expressed juice is an opaque fluid, of a gray or dingy olive colour; it is composed of two parts, one solid, the other fluid; united, more or less intimately, according to circumstances.

We will first consider the solid part; the examination of which is very important, on account of the difficulties it offers to the manufacturing of the sugar.

The dregs, or feculencies, are some of the solid parts of the cane, which unavoidably mix with the juice in the operation of obtaining it; of these there are two kinds. The first, or coarser part, proceeds from the rind, and, together with a portion of mucilage, contains a quantity of green resinous matter; the other is an extremely fine powder; it comes from the pith, and its proportion is increased according as the vessels of this substance are weaker; it also contains mucilage, which is sometimes very intimately united with it.

Several agents, such as air, heat, alkalies, &c. decompose the expressed juice, and separate the feculencies from the fluid part. When this juice is exposed to the air in a large shallow vessel, the feculencies separate and fall to the bottom; the fluid being drawn off, is of a pale lemon colour, caused by the mucilage which it still retains. When this juice is exposed to the air and sun, the water which it contains evaporates in a uniform and gradual manner. This slow evaporation is most favourable to the regular and crystalline union of the particles of sugar. It then appears under the form of crystals, having their surface varnished with a slight yellow tint by the mucilage.

This method of drawing off the juice, and of extracting the essential salt, is certainly the most natural

and simple. But, unfortunately, the quickness with which this juice passes into fermentation, makes it totally impracticable on a large scale, and renders promptitude in boiling the juice, one of the greatest requisites in a sugar house.

In making choice of such means as we can employ, however, we should endeavour to approach as near to the natural and simple as possible.

Heat decomposes the juice of the sugar cane, in common with almost all expressed juices; but its action, even when carried to the strongest degree of ebullition, rarely suffices to separate entirely the feculencies of the second sort, it often even favours their more intimate union with the fluid parts. We are in such cases obliged to have recourse for their separation to alkalies, which are invariably employed, notwithstanding there may be circumstances when heat alone would suffice to separate completely both kinds of feculencies. While heat separates the impurities which unite together in large flakes, it also takes from them all the mucilage it can dissolve; and thus places the juice in less favourable circumstances for extracting its essential salt, than if, as before described, it had only received the action of the air.

Alkalies act on the juice of the cane in a stronger and more marked manner than any other agent. They decompose it immediately, by separating the two kinds of feculencies, in very large flakes, which precipitate, if the operation is performed cold; but at the same time, the alkali, in proportion to its causticity, takes from them the mucilage they contain, and combining with it, imparts to the juice the smell of leys.

The facility of separating the feculencies, is in pro-

portion to the quantity of resinous colouring matter which they contain, as heat and alkalies are more likely to diffuse, and the latter even partially to dissolve the second kind of feculencies, when they are without this resinous matter, or contain it in only a small proportion.

It is thus easy to perceive, that alkalies, in taking from the feculencies all the mucilage they contain, and, under some circumstances, even partially dissolving those feculencies, must be detrimental to the crystallisation of the essential salt, on account of the mucilage which has in this manner entered into combination with the alkali. Alcohol has no other sensible effect on the feculencies of the expressed juice, than that of arresting, for some hours, their spontaneous decomposition. Acids seem to diffuse them still more, and favour their union with the fluid part, changing their green tint to brown.

If the fresh juice of canes is left to itself, the feculent parts are soonest decomposed, and an acetous fermentation commences. Of the first kind of feculencies, one portion sinks to the bottom, and the other rises to the surface, while the acid thus produced, acts upon the second sort of impurities by diffusing them through the whole fluid mass.

When the acetous fermentation is well established, it is continued for several weeks, gradually decomposing the essential salt.

The acid which is generated at the very commencement of spontaneous decomposition, holds the feculencies in more intimate combination with the fluid part and the longer this fermentation goes forward, the more difficult becomes the separation by heat and alkalies. If any feculencies are retained in the syrup, they very

much impede the crystallization of the sugar, and sometimes even render it impossible of accomplishment.

This strongly shows the necessity of operating, immediately after expression, upon the juice, which cannot be left twenty minutes in the receiver in hot weather without indications of incipient fermentation.

When the juice, by the application of heat and alkalies, is deprived of the feculencies of the first, and part of those of the second kind, it passes, if left to itself, into a state of vinous fermentation, which immediately decomposes and separates that portion of the feculencies of the second sort, which still remains in combination with the fluid; carbonic acid gas is given off, and if the fluid is concentrated at this incipient stage of fermentation, it yields sugar of very superior quality.*

The expressed juice of the cane, deprived of its feculencies, contains the sap and mucous juices, united with mucilage, forming together an homogeneous fluid, clear, transparent, and of a yellow colour. We will designate this by the term *cane liquor*, to distinguish it from the impure juice on the one hand, and from concentrated syrup on the other.

The proportion and quality of the different juices vary more or less in the cane liquor, depending not only on the kind of cane, and the season, but also on numerous other local circumstances. The water which the liquor contains must be considered under two different relations; the one holding the mucus

* I have twice obtained very fine sugar from juice partially clarified, which had undergone a vinous fermentation during eighteen or twenty hours.—*Dutrone.*

and mucilage in a saturated solution: this is called the water of solution, and, combined with these matters, takes the name of syrup; the second is the superabundant water, and is generally from sixty to eighty-five per cent. in quantity over and above the water of solution.

In order to exhibit the relative proportions of water and syrup, we give the following Table, taken from Dr. Dutrone's Work, an authority which we have uniformly found so accurate, that we do not hesitate to take this Table as a guide. It is constructed from experiments made with solutions of very pure sugar, taken at all degrees of the saccharometer. By means of the saccharometer and this Table, the proportion of sugar contained in the expressed juice may be immediately ascertained, and the quantity of water which must be evaporated to bring it to the point of saturation, can be accurately determined. It will also enable us to judge, by approximation, of the proportion of water and soluble matter contained in juices of middling and bad qualities.

The saccharometer is a very simple but useful instrument for ascertaining the specific gravities of fluids, we believe it is very rarely employed in our Colonies. If it were adopted, the operator could not fail to find in it the means of conducting the process of sugar boiling with greater certainty and precision than without its assistance. The saccharometer invented by Monsieur Baumé is frequently used in the sugar refineries of England as well as of France.

TABLE

Of the quantity of Sugar contained in one hundred pounds of expressed cane juice, or syrup, of good quality; and also of the quantity of water that must be evaporated, to reduce the same to the state of saturated syrup, taken at each degree of the Saccharometer.

Scale of Baume's Degrees.	Weight of Sugar in each 100 lbs. juice or syrup.			Weight of Water in each 100 lbs. juice or syrup, beyond the water of solution.			Specific gravities of solutions at each Degree.			
	lbs.	oz.	dr.	lbs.	oz.	dr.	Deg.	Sp. gr.	Deg.	Sp. gr.
1	1	13	6	97	„	15	1	1006	35	1312
2	3	10	12	94	1	14	2	1013	36	1324
3	5	8	3	91	2	13	3	1020	37	1336
4	7	5	10	88	3	12	4	1028	38	1349
5	9	3	„	85	4	11	5	1035	39	1361
6	11	„	7	82	5	10	6	1042	40	1374
7	12	13	14	79	6	9	7	1050	41	1386
8	14	11	4	76	7	8	8	1058	42	1400
9	16	8	11	73	8	7	9	1065	43	1413
10	18	6	1	70	9	6	10	1073	44	1427
11	20	3	8	67	10	5	11	1081	45	1441
12	22	„	15	64	11	4	12	1090	46	1456
13	23	14	5	61	12	3	13	1100	47	1470
14	25	11	12	58	13	3	14	1106	48	1485
15	27	9	2	55	14	1	15	1114	49	1500
16	29	6	9	52	15	1	16	1125	50	1515
17	31	4	„	50	„	„	17	1132	55	1618
18	33	1	6	47	„	15	18	1140		
19	34	14	13	44	1	14	19	1148		
20	36	12	3	41	2	13	20	1157		
21	38	9	10	38	3	12	21	1167		
22	40	7	1	35	4	11	22	1176		
23	42	4	7	32	5	10	23	1186		
24	44	1	14	29	6	9	24	1195		
25	45	15	4	26	7	8	25	1205		
26	47	12	11	23	8	7	26	1215		
27	49	10	1	20	9	6	27	1225		
28	51	7	8	17	10	5	28	1235		
29	53	4	15	14	11	4	29	1246		
30	55	2	5	11	12	3	30	1256		
31	56	15	12	8	13	2	31	1267		
32	58	13	3	5	14	1	32	1278		
33	60	10	9	2	15	„	33	1289		
34	62	8	„				34	1301		

A saturated solution of very pure sugar contains five parts of sugar and three parts of water. This is indicated by 34° of Baumé's saccharometer, at the temperature of 82° Fahrenheit.

The variation in the proportion of superabundant water is sometimes so considerable, that Dutrone found in the same plantation, at three months' interval, cane juice differing from 5° to 14° of the saccharometer. The first contained, according to the Table, 9 lbs. 3 oz.; the second 25 lbs. 11 oz. of sugar in 100 lbs. of juice.

Cazaud found that, in January, four hundred gallons of juice commonly yielded forty-eight gallons of sugar and molasses, one with the other; in February, from fifty-six to sixty-four; in March, from sixty-four to seventy-two; and in April, sometimes eighty. He affirms that the dryness of the season, and not the age of the canes is the cause of this increase of produce. He considers the greatest relative maturity of the canes to be when the juice is four parts water and one part sugar and molasses. Edwards considers the average proportion to be eight parts water and two sugar and molasses, the latter equally divided.

In the Island of St. Vincent one pound of sugar is said to be obtained from each wine gallon of the best cane juice; while from twenty gallons of middling quality only sixteen pounds of sugar are produced; and when the juice is watery, only the same quantity of sugar can be obtained from twenty-four gallons.

In Grenada, it is said that one hundred gallons of juice, when expressed in April and May, yield one hundred and twelve pounds of sugar; while the same quantity of juice, expressed in January, will sometimes yield only half that weight.

The result of an examination into the actual produce of a considerable estate in Jamaica during eleven years, gives 122 lbs. of sugar as the highest produce of 100

gallons cane juice, 95 lbs. as the lowest, and 108 lbs. as the average produce.

The mucous juice, the proportion of which varies in the inverse ratio to that of the water, varies again in its quality, with reference to the degree wherein it contains the elements of its essential salt.

Cane liquor of the best quality is that in which the mucous juice is entirely in the state of essential salt; that of middling quality has a portion of the mucous matter deprived of some of the requisites for its formation into essential salt: this state is designated saccharine mucous juice. The cane liquor of bad quality has a portion of what has been described under the name of sweet mucous juice. These distinctions show that the juice is middling or bad, in proportion as it contains mucous juice in the saccharine or sweet states.

The juice of canes just arrived at their full growth is in the sweet mucous state; this, when clarified and concentrated, assumes a very deep brown colour, and becomes syrup of very thick consistency. If the heat applied be greater than 221° Fahrenheit, it will be decomposed. If the juice be expressed from the cane while maturating, the mucous juice is then in the saccharine state, and when clarified and concentrated, produces syrup of a very deep colour and thick consistence; it can scarcely support 225° Fahrenheit without decomposition, while the mucous juice, in the state of essential salt, remains undecomposed at the heat of 260°, and pure sugar will bear exposure to 300° and even higher, without injury.

It can now be easily perceived how greatly the presence of sweet and saccharine juices is injurious to the

manufacture of sugar, when, as is now always the case, degress of heat are used sufficiently high to decompose them. The mucilage is more or less abundant, according to the nature of the cane and the situation in which it grows. It is the colouring matter of the juice, which varies from lemon colour to a deep brown, according as the heat and alkalies in separating this matter from the feculencies increases the proportion of mucilage which is held in solution by the fluid. We have already said that alkalies, combining with the mucilage, give intensity to its colour in proportion to their causticity; and the smell peculiar to the cane is lost in that of leys.

Mineral and acetic acids revive the yellow colour of the juice, and change it to amber more or less dark, according to their strength. The vegetable acids, such as cream of tartar, citric acid, &c. &c. weaken and partially destroy its colour; oxalic acid destroys it entirely, when the base of this juice, deprived of the colouring principle which held it in solution, shows itself under a solid form, white, and insoluble in all menstrua. It can readily be conceived that the mucilage, having for its base a substance which is only held in solution by a colouring principle, will injure the crystallization of the sugar in proportion to the quantity of that mucilage which is contained in the expressed juice; whence it may be concluded, that alkalies are injurious in proportion to their activity in separating the mucilage from the feculent parts, and that, in the necessity of employing them to clarify the expressed juice, we should carefully seek for every means of judiciously conducting the operation. This delicate and important office is, however, generally performed in the most slovenly and careless manner.

CHAPTER VII.

ON THE MANUFACTURE OF THE JUICE INTO SUGAR.

The buildings required for the manufacture of the juice into sugar, and their particular relative situations, are, of course dependant upon the size of the estate and its localities; it would therefore be idle to give any fixed rules for their dimensions; but, as the situation of all the other buildings is dependant on that of the mill, it is highly important to select the most eligible spot for its erection. There should be a fall from it to the boiling house, so that the expressed juice may flow without assistance from the one to the other. For the same reason, a fall from the boiling house to the still house, and again from the latter, to allow the refuse from the stills to run off, will be very desirable, while the lower the situation of the mill, compatible with these conditions, the better.

The canes are twice subjected to the action of the mill, by which means all their juice is expressed. Some planters place sieves in the mill bed, to intercept the coarser solid feculencies, and separate them from the juice; others recommend hair cloths or blankets for

this purpose, and it is matter for surprise that some such useful auxiliary is not generally adopted.

The juice, as expressed, flows from the mill bed into channels, through which it is conducted to the receivers; of these vessels there are generally two, placed either in the sugar house, or contiguous to it; which latter situation seems the most desirable, in order to keep the juice as cool as possible.

A trusty negro is appointed to watch over and direct the working of the mill. His first duty is, carefully to wash and cleanse every part and every vessel through which the liquor passes: the strictest attention must be paid to this, cleanliness being so essentially necessary to the manufacture of good sugar, that the best arrangements will prove nugatory if unaccompanied by it. The cylinders, mill bed, and channels, should be well sprinkled with lime whenever the work is stopped; for if any part of the impurities lodge within the joints or crevices, it becomes putrescent, and infects in a measure all the pure juice which comes in contact with it. All the utensils should be washed, every morning and evening, with boiling water and ashes, and afterwards rinced with cold water. A boy is employed in clearing away such refuse as might otherwise prevent the regular flowing of the juice, by forming obstructions in the channels. Others again are occupied in removing the crushed canes; these are designated cane trash, or magoss, and serve for fuel in the operations of the boiling house. They are carried from the mill to the trash house, which is a building usually about one hundred feet long, eighteen feet wide, and fourteen feet high; it consists of a double row of pillars, supporting a substantial roof, and

should be so situated, as to be at once easy of access from the boiling house, and yet sufficiently removed from the rest of the works to lessen the risk of fire. In properties of magnitude, two such buildings are necessary. The cane trash is carefully spread out in them, and means are taken to render it perfectly dry and fit for its intended purpose. In situations where rain is not frequent, it is sometimes heaped in the open air; but the provident planter will never be without some place of shelter for this very important agent in the manufacture of his sugar. If it be stored without proper attention to ventilation, fermentation will speedily be induced, and render the cane trash wholly unfit for fuel.

Many different constructions of furnaces and evaporating vessels of different forms, have been proposed, and some of these have been employed, in communicating the action of heat to the expressed juice.

The Dutch were the first to introduce the use of cast iron boilers into their American Colonies, following, most probably, the example of the settlers in the Island of Java, who, according to Rumphius, have employed vessels made of this material for more than a century and a half. The English colonists have generally found their advantage in using copper preferably to iron, although in some of our settlements cast iron vessels are employed. As we intend treating separately on this subject, we shall not in this place enter upon any description of different improvements, but merely detail the process as now performed, and describe the relative dimensions of the different vessels.

The juice, when expressed from the canes, runs into

a trough or tank. The power of the mill, and the size of this tank, bear, of course, some proportion to the magnitude of the property, and the tank or receiver should be of equal capacity with the clarifying copper, wherein the juice is first exposed to the action of fire. In some cases, the boiling house is furnished with only one clarifying copper; in general, however, two or three are employed, and, in some large concerns, four are provided. The large evaporating pan, into which the clarified cane-liquor is first conveyed, must be of equal, or nearly equal, magnitude with the clarifier; the second evaporator is of about two-thirds its capacity; another copper, again, is of about three-fifth parts the size of the second evaporator, and the last vessel employed, or teache, is about half the content of the third evaporator. There is considerable variation in the number of coppers employed, and consequently in their relative sizes also. Some large plantations are provided with a double set of coppers, when the clarifiers are placed centrally to the other vessels. We have been favoured with many details of the establishment and operations of a considerable and well-managed property in Jamaica, to which we shall hereafter take occasion to refer. The boiling house of this estate, which produces about 400 hogsheads of sugar annually, is provided with three clarifiers, each of 440 gallons capacity, one grand evaporator of equal magnitude, one of 300 gallons, another of 180 gallons, and a striking teache of 90 gallons, wine measure.

The clarifiers are known by different names in different Colonies, being sometimes called "racking coppers," and sometimes "cracking coppers," from their employ-

ment ceasing when the scum begins to "crack," or divide upon their surface. They are flat at bottom, and each is provided with a syphon, or cock, for drawing off its contents. They are hung to separate fires, and the chimney, with which their furnaces communicate, is provided with a damper for regulating the draught, and diminishing or stopping at pleasure the combustion of the fuel. The evaporating coppers and teache have only one fire-place, which being immediately under the latter vessel, it, of course, receives the strongest action of the fire, the effect of which is continued by means of flues under the other vessels, and the fierceness of the fire is usually such as to occasion a considerable ebullition even in the copper most remote from its direct influence. The furnace mouth and ash-pit are outside the boiling house, being protected from the weather by a shed, or by the prolonged roof of the building, under which a supply of fuel is placed. The duty of the negroes, who are stationed here, consists in replenishing the fire from time to time, as directed by the head boiler in attendance on the pans.

When the work of the boiling house is about to commence, a busy and cheerful scene ensues. Negroes are employed in cleaning and washing out the coppers, preparing the quick-lime, and making lime-water. The mill is put about, and as soon as sufficient canes are expressed to fill a receiver with juice, it is made to flow through a channel, lined with lead, into one of the clarifyers, and a fire being lighted under this, the alkali, or *temper*, is stirred into the juice. The quantity of alkali employed is sometimes determined by measure, or weight, but is more generally regulated by the practical knowledge or

discretion of the boiler. Lime in the solid form, or mixed with cane juice to the consistence of cream, is commonly used: lime-water would appear to be preferable, and it is matter of great surprise that, seeing what serious evils ensue from the improper use of alkalies, some judicious method for regulating their application with greater precision should not be adopted. A more rational plan has been partially pursued by some planters, who provide a graduated glass measure, wherein the lime is added to the fresh expressed cane juice, in known proportions, until appearances indicate that a proper dose has been given. A knowledge of the proper relative quantities of juice and lime being thus obtained, lime is added to the whole of the expressed juice in the same proportion, and this is mixed up cold in the receiver, previous to its transmission to the clarifier. Another advantage would appear to follow this method, in the diminished tendency of the juice to fermentation, after the addition of the alkali. The very injurious effects resulting from the intemperate use of lime, have been related to us by the proprietor of an estate in the Island of St. Christopher's, the produce from which had been uniformly inferior for upwards of fifty years. It had been the practice to use three pounds of lime in the clarification of three hundred gallons of cane juice; but, during the last few years, this proportion has been diminished to seventeen ounces of lime for the same quantity, and the sugar has, in consequence, been improved in quality and value many shillings per cwt.* As the

* Some planters allow a pint of Bristol lime to every hundred gallons of liquor, but this proportion is generally found too large.

juice in the clarifier becomes heated, the feculent parts separate and rise to the top in the form of scum. The juice must not be allowed to boil, and its temperature in this vessels should never exceed 210° Fahrenheit. When the scum rises in blisters, which "crack" or divide into white froth, an effect which is generally produced in about forty minutes, the fire is damped; after which, if circumstances will admit of the delay, the cane liquor is allowed to remain undisturbed in the clarifier for twenty or thirty minutes, and even longer, during which period there ensues a more complete separation and rising of the impurities. The liquor is then carefully racked off, either by means of a syphon, which draws up a fine defecated stream through the scum, or through a cork at the bottom, and about a twentieth part of its original contents remaining in the clarifier, being the separated impurities of the juice, are sent as refuse to the still-house. The advantage of clarifying the juice in this manner, rather than by forcing an immediate ebullition, is very great. It saves a vast labour in the scumming, which would likewise be very imper-

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The lime is perceptible in the sugar, both to the smell and taste: precipitates in the pan a black insoluble calx, which scorches the bottom of the vessels, and is not detached without difficulty. I conceive, therefore, that little more than half the quantity above-mentioned is a better medium proportion, and in order that less of it may be precipitated to the bottom, an inconveniency attending the use of dry lime, Mr. Bousie's method of dissolving it in boiling water, previous to mixing it with the cane juice, appears to me to be highly judicious.—*Edwards's West Indies.*

It is generally supposed that alkalies are required to neutralize a free acid which is found in the juice. We shall presently endeavour to show that this opinion is erroneous.

fectly performed, as the whole body of liquid would then circulate with great rapidity, and would carry down again the impurities which had risen to the surface. The liquor passes from the clarifier, through a channel, to the largest evaporating pan, and if the expressed juice was of good quality, and the clarifying has been carefully and judiciously conducted, the liquor will appear nearly transparent, and of a light white wine colour. If in this stage of the process the cane liquor should not take this appearance, it very rarely happens that any subsequent operations will convert it into good sugar.

Arrived in the evaporating copper, the cane liquor is now suffered to boil; the scum, as it rises, is carefully removed by scummers, until the juice grows finer and somewhat thicker, and is so far reduced in quantity by scumming and evaporating, that it can be contained in the next boiler, into which it is then laded. The same process is continued in this copper, and if the cane liquor is not so clear as is wished, or expected, some lime water is thrown into it. The propriety of this is further concluded on, if the liquor should prove at all ropy. Many other signs are mentioned as indicating the state of the liquor to an experienced eye; these, however, are very often fallacious, and lead to material errors. The liquor is said to have a good appearance in the second copper when the froth, in boiling, rises in large bubbles, and is but little discoloured. When the scumming and evaporating have again sufficiently reduced the cane liquor, which may now be said to have reached the state of syrup, it is transferred to the third boiler, and so on to the last, where the fire is more immediately applied,

and which is called the striking teache. The scumming is continued throughout the process. The coppers are sometimes kept constantly filled by lading the liquor from one to the other, as it is diminished by evaporation. The effect proposed by this is to prevent, or rather to mitigate the evil of burning the syrup, by keeping the whole surface of the copper in some sort protected from the over-heating which would ensue in its upper portion, if left uncovered by the syrup, which, splashing against the sides of the copper thus overheated, would be materially injured by carbonization. Some planters do not, indeed, extend this practice so far as the striking teache, knowing, by experience, how necessary it is to remove the concentrated syrup as quickly as possible from the intense degree of heat to which it is subjected in this latter part of the boiling process. The syrup remains in the striking teache until, by evaporation, it is so far concentrated as to be capable of granulating in the cooler. When the ebullition in this vessel is exceedingly violent, the syrup is kept from rising too high by beating it and breaking the bubbles with the ladle, or with a wooden spatula. The proper point of concentration having arrived, the fire is damped or drawn, and the sugar is laded into the cooler. The manner of judging of the required consistency, is either by observing the granulation as the syrup cools on the back of the ladle, which is dipped into the teache for that purpose, or more commonly by taking a small portion off the ladle upon the thumb, then bringing the forefinger in contact with the same, and again separating them, noting the length to which a thread of syrup can be drawn before it breaks; if this extends to about

the half of an inch long, it is judged that the sugar is fully boiled, that it is "proof." However much this plan may appear to be sanctioned by successful experience, it is evidently a very rude and unscientific test. A better mode was suggested by Mr. Proculus Baker, in a treatise published by him in the year 1775. He says, "provide a small thin pane of clear crown glass, set in a frame, on this drop one or two drops of the subject, and carry it out in the open air; observe the subject, and more particularly whether it grains freely, or whether a small edge of molasses separates at bottom. This method is used by chemists to try evaporated solutions of all other salts; it may appear, therefore, somewhat strange it has not been adopted in the boiling house." We believe, however, that this simple and efficacious plan, so long ago recommended, has not yet been generally adopted, and in some Colonies is, perhaps, unknown.

Great care and expedition in striking are required to lessen the injury from burning, an evil which is necessarily operating, from the moment the syrup reaches the striking teache, and increasing progressively, as its concentration leaves a larger portion of the surface of the vessel exposed unprotected to the direct action of the fire. It has been constantly observed, that each successive ladleful of sugar which enters the cooler, is darker in colour, and consequently worse in quality; and so excessive is the degree of heat employed, that if the teache is not immediately replenished, it becomes red hot, to the manifest injury of the vessel itself, as well as of the syrup next transferred to it.

The coolers are wooden vessels to which the sugar

passes from the striking teache; these differ materially in size, varying from four to eight and even ten feet long, and from three to five feet wide and one foot deep. From three to six of these, according to their dimensions, are ordinarily found sufficient in a sugar house for the crystallization of the sugar. Two separate emptyings of the teache, or skippings, are mixed intimately together in these vessels. The coolers are placed together, generally in the boiling house, but sometimes in a shed adjoining. The sugar soon crystallizes in them, but the more gradually this is done, the more perfectly the process is effected, the larger is the grain of the sugar, and the more easily is it cured by the draining off of the molasses. It is likewise of importance that the sugar should remain a sufficient length of time in the coolers before being put into hogsheads, or, as it is technically termed, "potted." Time is absolutely required for the proper and perfect crystallizing of all salts, and it is to be feared that the too recent potting of sugar, disturbing this operation of nature, occasions much to drain away from the casks in the form of molasses that would otherwise assume the crystalline state.

The scum which is removed from the cane liquor and syrup, in its progress towards concentration, is taken, equally with the feculencies collected in the clarifier, to the still house. Something might be saved by placing this scum, as it is removed from the evaporators, in cans, having false bottoms, perforated, to allow of the subsidence of the clear liquor, which might then be returned to the coppers, instead of being less profitably used in the still house.

The curing house is a large building contiguous to

the boiling house, and usually built at right angles from its centre; the two forming together the shape of the letter T. The lower part of this curing house is occupied by a cavity, called the molasses cistern, which is lined, sometimes with cement, and sometimes with planks, lapping one over the other. A preferable plan which is also sometimes adopted, is to line this cistern with lead; it is generally about six feet deep, and its bottom always forms an inclined plane. Over this cistern, and level with the floor of the boiling house, is an open frame work of strong joists, leaving a gangway in the middle, which is boarded. The hogsheads intended to receive the sugar are ranged upright on this open floor; several holes of an inch diameter are bored in their bottoms, into each of which holes is placed either a plantain stalk or an expressed cane of sufficient length to reach to the top of the hogshead. The sugar having remained in the cooler until crystallized and cooled to a certain degree, is transferred to the hogsheads, through the holes in the bottom of which the molasses drains into the cistern below. The fluidity of the molasses is promoted, and its separation from the sugar consequently assisted, by keeping the curing house close and warm. This building should be sufficiently capacious to contain as many hogsheads of sugar thus placed as can be made on the estate during three or four weeks; in this time the sugar, although never entirely freed from molasses, a portion of which always remains entangled amongst the crystals, will become tolerably dry and fit for shipment. It is a good plan, and will abundantly repay the trouble it occasions, if, previously to heading up the hogsheads, the portion of sugar which

is least perfectly cured is taken from the bottom of the cask, and its place is supplied with dry sugar. The portion thus removed may then be returned to the cooler, and if hot sugar from the teache be then poured upon and mixed with it, the subsequent curing will be more perfect than the first.

We conclude our description of the process of manufacturing cane juice into sugar as usually conducted, with the following summary of the operations during eight consecutive years, of a sugar house in Jamaica, where all the arrangements are judiciously made, and the process is most carefully conducted.

Year.	hds. of sugar produced, *each* 20 *cwt.*	allons of juice required per hhd.	Month of greatest produce.	Hhds. sugar made during that month.	Gallons of juice concentrated in that month.	No. of skippings.	Produce of each skipping in sugar.			No. of mins. employed in each skipping.
							cwt.	qrs.	lbs.	
1820	462	2074	April	116	230,700	911	2	2	5	47½
1821	357	2068	April	94	184,040	612	3	0	6	56½
1822	372	2333	April	88	202,960	664	2	2	17	52
1823	349	2195	March	83½	183,310	697	2	1	17	49½
1824	338	2023	March	104	208,400	961	2	0	18	36
1825	294	2100	February	103	218,660	1045	1	3	25	33
1826	431	2173	March	105	230,120	1095	1	3	19	31½
1827	329	2255	April	99	219,260	998	1	3	26	34½

Note.—The measure of capacity employed was the wine gallon of 231 cubic inches.

The sugar, the manufacture of which has been here described, is known as muscovado, or raw sugar, and is the material used by sugar refiners in making white, or loaf sugar. It is generally used for domestic purposes in England. There is another description of sugar, which

some years ago was very much consumed here, and was known as Lisbon sugar. This is still in very general use on the continent of Europe, and from the additional process which it undergoes, is called *clayed sugar*. In the Island of Cuba, and in the Brazils, no other is made; it is still extensively prepared in the French Islands, but seldom in our own Colonies, except for their home use.

To describe the process of claying we must retrace our steps to the syrup concentrating in the striking teache, where the degree of heat applied should be somewhat lower than is employed for making muscovado sugar. Large coolers are placed near the teache: into these two successive skippings are mixed. The sugar is then put into conical earthen vessels, called by the French *formes*, and by the English planters *pots*. Those employed by the French are two feet in height, and their base thirteen or fourteen inches in diameter; the vertex is pierced with a hole of about an inch in diameter, which is stopped with a bung or wooden peg. The cones used by the Portuguese and Spaniards are larger. The curing house for claying requires to be much larger than that used for curing raw sugar. It is most commonly a square building, divided into compartments by cross pieces of wood running parallel to each other, and forming frames five feet wide, placed at right angles with one side of the building, and reaching to within two or three feet of the opposite side; these are intersected by other cross pieces of wood, and the whole is supported by dwarf posts two feet and a half high. These compartments are about eighteen inches apart from each other, and this interval serves

as a passage for the labourers engaged in the operation of claying. The sugar, after cooling in the forms for fifteen or eighteen hours, is conveyed here from the boiling house. The holes of the forms are then unstopped, and each is placed in a pot whose size bears relation to that of the form. After being left thus for about twenty-four hours, or as long as any syrup will drain spontaneously from them, they are placed over other pots, and being carefully ranged in the compartments, the clay is applied to the sugar.

The object to be attained by claying, is to remove the portion of syrup which still remains entangled in the interstices formed by the aggregation of the crystals of sugar in the conical mass. This object is effected through the means of water. The base of the cone or loaf of sugar is somewhat loosened, and then pressed evenly down, and an argillaceous earth, diluted with water to the consistence of thin paste or pulp, is poured over the levelled surface of the sugar. The clay performs the office of a sponge, allowing the water to percolate slowly through the sugar; the syrup which it contains, is thus diluted and rendered more fluid, and, descending through the crystals to the lower part of the form, drains into the pot placed beneath to receive it.

Every kind of argillaceous earth may be successfully employed for this purpose, provided it is properly prepared. The vessels in which the clay is beaten and diluted, are constructed of masonry and lined with cement; they are troughs usually from five to six feet square, and four or five feet deep.

When the magma of clay first employed, has parted with all its water, it is taken off the base of the loaf and

replaced by a second supply, and this again by a third quantity; when this last is dry it is removed, and the loaf is left in the form for twenty days longer, that the sugar may be entirely freed from syrup. It is then taken out of the form and exposed for some hours to the rays of the sun, on a horizontal plane of masonry. After this it is kept for a fortnight in a stove, to which a degree of heat is applied that entirely evaporates the water which remains after claying. The stoves, which adjoin the curing house, are built of masonry nearly twenty feet square, having the interior provided with different stages whereon the loaves are ranged. When sufficiently dried, the loaves are removed from the stove and pulverized in wooden trays from twelve to fifteen feet long, and from three to four feet wide. The sugar thus pulverized, is put into hogsheads and pressed down, that the casks may contain as much as possible. It is then exported under the name of clayed sugar. That shipped from Cuba is called Havanna sugar, from the name of the principal city and port of the Island, and is brought to Europe in a different state. The loaf, after stoving, is divided into three portions: the base is called white, the middle yellow, and the small part brown. These portions are packed separately in wooden boxes, each containing from three to four hundred weight. A similar system is followed in Brazil; the boxes, which are much larger than those of Cuba, are called chests, and each contains nearly three quarters of a ton of sugar.

It is calculated, that about one-sixth part of the crystalline sugar is dissolved and runs off in the operation of claying; this, together with the extra labour and uten-

sils required, are not thought to be sufficiently counterbalanced by the improvement in quality. Sugar is, therefore, very seldom clayed for exportation in the English Colonies.

The syrup which runs from the forms before the application of clay, is called coarse syrup; the draining during and after claying, is fine syrup. Two boilers are fixed in the curing or boiling house, for the purpose of boiling the syrup; the coarse and fine syrups are always treated separately. They are boiled to a heat of about 220° or 230° Fahrenheit, and the different products of the boilers are distributed among coolers provided for the purpose. As soon as crystallization commences in these coolers, the sugar is transferred to the forms, and treated in exactly the same way as at the first boiling. The drainings from this second boiling are taken to the still house, fermented and distilled.

CHAPTER VIII.

ON THE DISTILLATION OF RUM.

Scarcely any of the useful arts have more benefited by the researches of science than that of distillation, for the improvement of which many chemical discoveries have been made available. Processes for the production of ardent spirits are so strictly analogous in all countries and with all substances capable of yielding alcohol, that improvements in those processes, wherever they originate, are at once seen to be available every where; a remark wholly inapplicable to many other operations, and peculiarly so to the production of sugar from cane juice, which bears but little real analogy to other apparently similar manufactures. It is, perhaps, for this reason, that greater improvements in the operations of the boiling house have not been effected, while considerable advances have been made in the manufacture of rum, both with reference to its quality and the cost of its production. This adoption of improved methods of distillation, although rapid, is, however, far from being general; and it may, perhaps, be well to detail the

mode more usually pursued in the Colonies, deferring to a later portion of the work, our description of those improvements.

The still houses in sugar plantations vary in size according to the magnitude of the property. They are in general substantially built of stone, and are commonly equal in extent to both the boiling and curing houses. For a plantation whose yearly produce averages two hundred hogsheads of sugar of sixteen hundred weight each, two copper stills, one of one thousand and the other of six hundred gallons, with proportionate pewter worms, are usually provided. Should there be the advantage of a running stream of water, a tub, barely large enough to hold the worms, will answer every purpose; but if the whole dependance is on pond water a stone tank capable of holding twenty or thirty thousand gallons will be necessary. Into this the worms of both stills may be placed, and fresh water being from time to time added, it will remain cool enough for condensing the spirituous vapours.

In addition to the stills, there must be provided two cisterns, one of three thousand gallons for the lees,* or spent wash of former distillations, the other to contain the scummings; and ten, twelve, or more fermenting vats, each of equal capacity with the largest still. In Jamaica cisterns are universally preferred to vats for fermentation, as being more durable, less liable to leak-

* In Jamaica, Barbadoes, and many other of the old Colonies, the spent wash is always called *dunder*, a corruption of the Spanish word redundar, retained from the original settlers, or introduced by the first planters from Brazil, the Portuguese word being similar to the Spanish.

age, and less influenced by changes of weather, than wooden vessels. One or two pumps for transferring the wash to the still and for pumping out the lees are necessary, and a sufficient number of store butts must also be in readiness to contain the spirit when distilled.

Molasses, scummings from the clarifiers and evaporating coppers, and sometimes even raw cane juice, purposely expressed from the cane, are the matters subjected to distillation; these must be diluted with water; the lees, or feculencies of former distillations, are likewise added, to supply the necessary ferment or yeast. It is sometimes the practice to preserve the lees for this purpose from one crop to another,* but this appears by no means adviseable, and it would be better to obtain the fresh fermentable matter required from a fermented mixture of sugar and water. The use of spent wash is said to occasion the production of a greater proportion of spirit than can be obtained without its assistance; but if this be the case, it would seem to imply some defect in the previous fermentation or distillation.

In the Windward Islands, the scummings, lees, and water are sometimes mixed together in equal proportions. When these ingredients are well incorporated together, and proper attention has been given to temperature, fermentation will be sufficiently advanced in twenty-four hours for the molasses to be added, which is then done in the proportion of three gallons for each one hundred gallons of the fermenting liquor. In one or two days after,

* Some persons soak woollen cloths in the fermenting froth of the vats, and carefully dry and preserve these, to be introduced as ferments at the beginning of the ensuing crop.

when the whole is in a high state of fermentation, a similar proportion is added. The heat of the wash while fermenting should never be suffered to exceed 94° Fahrenheit. If the fermentation should be languid, the addition of hot water will promote it, and, on the other hand, if it works too violently, it may be abated by cold water. Six gallons of scummings are held to be equal to one gallon of molasses, and as one hundred gallons of wash, composed of one-third scummings, will be equal to five gallons and five-ninths of a gallon of molasses, and the subsequent addition of six gallons of molasses increases the quantity to eleven and five-ninths in each one hundred and six gallons, the sweets in this wash are now therefore in the proportion of about eleven per cent. The practice in this respect varies in different Colonies. A very usual mixture is ten gallons of molasses, twenty gallons lees, thirty gallons scummings, and forty of water, the proportion of saccharine matter being, therefore, fifteen per cent. In Jamaica fifty gallons of dunder are added to six gallons of molasses, thirty-six gallons of scummings, equal to six more gallons of molasses, and eight gallons of water, making the proportion of sweets exactly twelve per cent.* The whole quantity of molasses is added soon after fermentation has commenced, which appears a preferable method to that before described, as the successive operations tend to check fermentation, and consequently lengthen the process. Notwith-

* The use of dunder should be proportionate to the quality as well as the quantity of sweets; since its office is to dissolve the tenacity of the syrup. Dunder largely applied, though it may increase the quantity, certainly injures the flavour of the spirit.—*Edwards's West Indies.*

standing the general use of spent wash in setting the fermenting vats, it appears very doubtful whether so much real advantage results from it as to counterbalance a very probable evil in respect to the quality and flavour of the spirit obtained; and it might be well to put this matter to the proof by using some other substance as a ferment for the wash during such a period of the crop as would afford means of judging fairly between the two systems. It can hardly be necessary to point out the propriety of carefully examining, previous to their use, the state of the lees, as, should they, by any accident, have become infected, the wash will, of course, be contaminated, and the produce cannot prove good.

In some distilleries, the proportion of sweets amounts to fourteen or fifteen per cent. beyond which it would seem improper to go; for, if the viscidity of the liquor is such as not to allow perfect freedom of motion to the acting particles, they become entangled, and their beneficial agency is impeded; and even where the proportion of sweets is not sufficient to act in this manner, and yet is greater than above-mentioned, fermentation will be checked by the too abundant formation of alcohol, the presence of which impedes the fermentation of all bodies. Should there be too great a portion of sweets in the state of fermentation, so much alcohol will be formed that the process will cease prematurely, and preserve part of the sweets from further decomposition.

In the act of fermentation, carbonic acid gas is generated most abundantly, and, if this is allowed freely to escape, the process is accelerated, and alcohol is produced by the decomposition of the sweets, or fermentable matter. But it is adviseable not to allow the car-

bonic acid gas to escape too freely, as in such case it will act as a carrier to a portion of the alcohol, and the wash, as a necessary consequence, will yield less spirit. With the view of preventing this, it has been proposed to conduct the process in vessels wherein atmospheric air cannot enter, and to allow the carbonic acid gas freely to escape through a wide tube, whose further extremity is immersed one or two inches in water. This arrangement would add to the strength of the wash, and lessen the tendency to acetification; but, on the other hand, it would certainly somewhat retard the completion of the process. Fermentation is always conducted most regularly and satisfactorily in vessels of large capacity, and where care is taken to preserve an uniform temperature in the building.

When the fermentation has proceeded favourably, it will generally be completed in from five to seven days. The attenuation of the wash allows the subsidence of the crust which had formed on the surface, the fluid becomes clear and pungent to the taste, and a few globules of carbonic acid gas are slowly thrown up. The liquor should now be conveyed to the still before the next or acetous stage of fermentation can commence. With every care and caution that can be used, however, there will sometimes be a tendency to acetous fermentation, and it is of importance that this should be checked at the earliest moment by the application of some alkaline earth, for, in proportion as acetic acid is produced, the alcohol held in the liquid will disappear, and its rapid acetification will ensue. The use of caustic alkaline earth, such as lime, must be very cautiously adopted for this purpose, since, although it at once checks both vinous

and acetous fermentation, it tends to deteriorate the wash, and predisposes it for the putrefactive or last stage of fermentation. Dr. Higgins proposed that a basket, containing lime-stone, should be suspended in the wash, as the means of checking or preventing the acetous fermentation, and this plan is sometimes adopted at the latter stage of the process with success. In general, however, this difficulty is avoided by proper arrangements, so that the wash may be distilled as soon as the vinous fermentation has ceased.

Cleanliness is an object of as much importance in the still-house as in the various operations of sugar-boiling. All dirty or extraneous matters tend to promote the putrefactive stage of fermentation, and injure the peculiar flavour of the rum. The distiller must be most particular in having the fermenting vessels scalded, or cleansed with lime-water every time they are used; and this is necessary not only to benefit the quality of the spirit, but because the vapours which rise from foul cisterns are extremely noxious.

Distilleries in Europe are invariably furnished with saccharometers, for the purpose of ascertaining the strength of worts or wash, and there is no good reason why this simple and philosophical instrument should not be more generally used in the Colonies. It must, surely, be adviseable to reduce all operations of this nature to certainty by the aid of science, rather than continue satisfied with the variable success attendant upon routine and established usage.

The still should be charged with not more than two-thirds of the quantity it is capable of containing. The liquor may be subjected at first to the influence of a strong

fire, as it is then in a state to imbibe caloric freely and without any injury to its qualities; but so soon as it has reached, or rather has approached, the point of ebullition, the fire should be slackened and kept as low as is compatible with a moderate rapidity of action in the still. By this means all accidents of foul running, or of blowing off the still-head, are avoided, and the spirit will be less charged with empyreuma than where excessive heating is allowed. The spirit is made to flow through the worm until no longer inflammable, and the produce from this first operation is called low-wines. The smaller still is then called into action for the purpose of re-distilling or rectifying. The first runnings from this still are very strong, the more spirituous vapours rising first in distillation, and the produce becomes gradually weaker until all the alcoholic vapour has been evolved. The latter and weaker portion is set apart from the stronger spirit and returned into the low-wines. It is usual to obtain about one hundred and thirteen gallons of proof rum* from twelve hundred gallons of wash. Where the spirit is produced at a higher degree of strength, as it is universally in Jamaica, and very frequently in our other Colonies, a smaller number of gallons is, of course, obtained, but the value is equal and the expenses for casks and transport are lessened.

Edwards says that, in very rich moist lands, the pro-

* The specific gravity of proof spirit, (water being one, or unity,) is 0.916. At the temperature of 60° Fahrenheit a cubic inch of proof spirit weighs 9 dwts. 19.73 gs. troy, or 8.62 dr. avoirdupoise. Heat expands spirits very sensibly; one gallon of alcohol at the temperature of 32° is expanded to 1.04162 gallons, at the temperature of 100° Fahrenheit.

portion which the rum bears to the sugar made is considered to be as three are to four, or eighty-two gallons of rum to every hogshead (sixteen cwt.) of sugar; but that the fair average is, perhaps, about two-thirds, or two hundred gallons of rum to three hogsheads of sugar. This is his calculation: the supply of scummings being generally about seven per cent. of the cane juice, suppose that two thousand gallons of cane juice are required for each hogshead of sugar, the scummings on a plantation making two hundred hogsheads per annum, will be 28,000 gallons, equal to 4,666 gallons of molasses. The draining in the curing-house averages about 60 gallons of molasses per hogshead; this on 200 hogsheads will increase the total amount of sweets to 16,666 gallons. The wash set at the rate of twelve per cent. sweets, should return 34,720 gallons of low-wines, which should give 14,412 gallons of rum, or 131 puncheons of 110 gallons each. Where it is the practice to return the scummings into the clarifier to be reboiled, the produce of rum is necessarily diminished. Much, also, depends upon the season, and upon the quality of the canes in this respect, and it is impossible to make any calculations that will approximate to the reality. On consulting the average returns for ten years of an estate in the Island of Grenada, we find the proportion of rum actually made is ninety-two gallons for each hogshead of sixteen cwt. of sugar. This is the average proportion; but if the examination is made with reference to individual years, we cannot establish any relative proportion between the quantities of sugar and rum. For example, in the year 1819, there were shipped 3049 cwt. sugar, and 18,791 gallons of rum, while, in the year 1827, the quantity of

sugar was 3024 cwt., only 25 cwt. less than the former year, and the produce of rum was 13,817 gallons, being a deficiency of 4974 gallons.

The system of management having been the same in both years, this considerable disproportion can only be ascribed to a difference in the quality of the cane-juice, attributable to variations in the seasons.

CHAPTER IX.

ON THE FRENCH METHOD OF MANUFACTURING SUGAR.

As St. Domingo is now blotted from the list of European dependencies, it may appear irrelevant to offer any description of the methods used in that island for the manufacture of sugar. We give, however, the following summary of Dutrone's account of the plans formerly pursued there by the earlier French settlers, and of the subsequent alterations in those plans, in order to show how much the art of sugar-making has always been neglected, as, even to the present day, there appears to be less improvement in the apparatus used, and in the knowledge of the art, than might have been expected in a branch where science can teach us so clearly and satisfactorily, what processes are best and most deserving our attention.

Dutrone asserts that the St. Domingo planters in his day retrograded in departing from the method first used by them. So clearly and convincingly has he pointed out the errors into which they fell, and so enlightened and scientific do his own views appear, that we cannot do better than contrast those errors with the plans offered

by himself, which could hardly fail of proving advantageous, as being founded on sound principles, while the former resulted from chance or expediency.

When the French first began to make sugar in America, they generally employed four, sometimes five, and even six or seven evaporating pans, all of different and relative sizes, on the same line, close to each other, having a separate fire place to each. The first of these boilers was the largest. A degree of heat was applied to it necessary to separate the feculent matters of the first sort, which came off in scum. In the second boiler the alkalies were applied to separate the impurities of the second sort, which were called greasy matter, because they often assumed that appearance. The third evaporated the juice to the consistence of syrup. A further application of alkali was then again used, if it were considered necessary. The fourth served to evaporate the juice then made into syrup; the boilers that were employed beyond this number were supplementary to the second and third. The product of each boiler always, of course, constantly diminishing by evaporation and scumming, could be transferred entire to each successive boiler, which lessened in size progressively. The contents of one boiler were never allowed to be transferred to another till they were brought to the most advantageous point. As each boiler had its own furnace, the fire under each could be damped when necessary, without stopping or retarding the work of any of the others. It was also the custom to *filter* the juice in passing it from one vessel into another; the filters used were made of linen or woollen cloths. The end proposed in the employment of alkalies was to take up the greasy

matter, in order that it might be more easily removed, and the sugar obtained purer.

The component parts of the juice were then considered as divided into a foul and blackish scum, a greasy matter, sugar, molasses, and water.

About the year 1725 the French adopted the English practice of making one furnace supply heat to all the boilers.

The method that was pursued till then was simple and easy, that which the new disposition of the boilers required, although very difficult to establish and follow, was, nevertheless, adopted, because it presented a great economy of fuel, and that was a very important object, wood, which was becoming very scarce, being then used for that purpose. To obtain this advantage, the difficulties and inconvenience attendant on the new method were disregarded.

This new plan continued to be practised in St. Domingo as long as the French retained possession of it, and is, we believe, very nearly similar to that practised in many of the Colonies to the present time; in exposing its errors, we are, therefore, not combating an obsolete system.

One furnace served for five boilers; these vessels were fixed in solid masonry along the side of the sugar house, while the fire-place opened outside the building, in the same manner as it does at present, and as has been described. The boilers being made of cast iron, could not then be procured sufficiently large for the purpose, and their capacity was therefore increased, by their setting being continued in a slope at top, forming a large brim or lip to them. Each of these boilers was

progressively smaller as the juice which they were to contain became less by evaporation; but this provision does not seem to have been managed so as properly to answer the desired end of pouring the whole contents of one vessel into another in succession: it seems, on the contrary, to have been sadly messed about, and the European reader is quite confused in the description of the various transfers from one boiler to another.

To each of these boilers a name was given: *grand*, *propre*, *flambeau*, *sirop*, and *batterie*. A description of the appropriateness of these titles, as given by Dutrone, would be more amusing than edifying; but, however, we may smile at these names, so characteristic of the fanciful distinctions of the French, we think we must avail ourselves of them in rapidly pursuing the divers in and outpourings, as we should otherwise be obliged to take a very round-about way in making ourselves intelligible. The juice immediately after expression, was made to flow from the receivers into the *grand;* the alkali was here put in, and when the juice was thought to be enough tempered, it was poured out into the *sirop* and *flambeau.* The *grand*, again charged, and again tempered, then parted with its contents to the *propre;* lastly, the *grand* was filled anew and tempered, the *batterie* being filled with water, and the fire lighted, the work commenced. The *sirop* and *flambeau* receiving more heat than the other two vessels filled with juice, ebullition took place in these more promptly, and as soon as the scum was removed, the water was emptied from the *batterie*, and half the contents of the *sirop* was put into it; if considered adviseable, more alkali was now added. The *propre* and *grand* became heated suc-

cessively, and the work of scumming went on. The evaporation being very rapid in the *batterie*, there was soon sufficient room in it for the remaining contents of the *sirop;* then another pouring business, the contents of the *flambeau* into the *sirop*, and half the contents of the *propre* into the *flambeau;* then the *batterie* could receive a fresh supply from the *sirop*, all changed places again in consequence, and half of the *grand* came to the share of the *propre.** The *batterie* received thus the evaporated juice of two, three, or four charges from the *grand*, according to the degree of richness and quality of the expressed juice, after it had, in passing successively through all the vessels, been tempered and scummed as much as the disposition and order of the work would permit. It was here concentrated until it indicated about 250° of Fahrenheit. (If intended for claying, the boiling was not quite so high.) When the contents of the *batterie* were concentrated to what was considered the proper point, the fire was damped, and the syrup poured into the cooler. The *batterie* was again filled by the series of exchanges, and this second product was rather more concentrated than the first; they were well mixed together in the cooler by a wooden stirrer, and were then poured into the crystallizing vessels, if for raw sugar, and into the forms if for claying. The work in the curing house then proceeded so exactly as it does at present in our Colonies, that it would be useless further to describe this process.

Dutrone remarks, that the iron boilers and the slopes

* Something similar to this injudicious practice still partially prevails in most of the Colonies.

in the setting are very serious inconveniences, and absolutely prevent that cleanliness which is so extremely essential in the manufacture of sugar.* The iron boilers are very fragile, and their fracture, by stopping the work, causes loss of time as well as of the vessel and its contents, and expense of repairs; alteration in the furnace, which must in part be demolished, in order to remove the broken vessel, and less solidity in the new masonry, which supports the new boiler.

A new vessel, a slope repaired, cause fresh dirt, and after all these inconveniences the danger still remains of seeing these accidents occur again immediately, either upon this vessel or another. It would seem that the elliptic form was given to them expressly for altering and decomposing the sugar. These boilers are plunged entirely in the fire, which, under the French system, is never damped in the repeated emptyings and fillings. The syrup which is below the point where they are set receives a degree of heat which it cannot support without being decomposed; this decomposition is always so considerable, that it carbonizes some of the sugar which forms an encrustation over the whole inside of the *batterie*. This is obliged to be cleansed several times a day, and the work is stopped, for the purpose of scouring and washing it out. This circumstance, of course, injures the syrup extremely, and gives to it a black tint.

However solid the slopes may be made, they are constantly breaking off and crumbling away; this does not,

* The French are considered to understand the theory of the art better than the English, but their extreme want of cleanliness, and of personal attendance in the boiling-house, present serious obstacles to their making good sugar.

in truth, stop the work, but pieces of the cement fall into the syrup, and its decay, when once begun, is very rapid, from the action of the syrup on the lime composing the cement. The repairing these slopes also causes loss of time and of materials, and occasions fresh dirt to all around. The situation of the furnace against the wall renders the duty of scumming much more laborious; as there is only access to the boilers on one side, the negroes only scum one part of the surface of the syrup, as they cannot carry the scumming over the whole without leaning over the boiler; to remedy this inconvenience, they are obliged to scum without relaxation.* It is impossible to establish a constant, regular, and easy progress in these boilers; the richness and quality of the juice cause it to vary unceasingly. The action of the fire upon each boiler, sometimes more, sometimes less, but always unequal, constantly deranges the whole series. But the irregularity of the night work does a great deal more mischief, by the difficulties which result from it, than even the boilers and their slopes, by their ill adaptation and want of cleanliness. The *grand* is usually charged with about two hundred and fifty gallons of juice; as this vessel is the farthest from the direct action of the fire, it often happens that the juice does not arrive at a state of perfect ebullition, and it receives the comparatively ineffectual action of the fire during an hour and sometimes even more. The agitation of the liquid attendant on the operation of lading it into the *propre*, causes the feculencies which had been separated

* This applies equally well to the present time, as the coppers continue to be set in a similar manner.

and were floating about in flakes, to be again intimately mixed with the juice, and the clarifying is thus rendered more difficult. Scarcely is the *propre* deprived of a part of its impurities when a portion of it must pass into the *flambeau*, which, not having been entirely emptied, receives, with the liquor it contains, one much less tempered and scummed; but some minutes after this mixture must be hurried from the *flambeau* into the *sirop*, where it is mixed with syrup much more scummed and evaporated. At last, when the *batterie* is charged, a part of the liquor of the *sirop* is put into it. This syrup is never completely scummed, and it is never evaporated beyond twenty degrees of the saccharometer of Baumé, sometimes even not beyond twelve. This syrup mixes with that already in the *batterie*, which is much more concentrated; the portion of feculent matter which it then contains becomes entangled in the viscid syrup, and cannot by any means be disengaged. The contents of the *batterie* are evaporated to the consistence of very thick syrup, fresh liquor is added, so that the contents of the *batterie* arrive twenty times to the state of thick syrup, and as often recede from it by the accession of fresh liquor from the *sirop;* this in its turn undergoes similar alternations almost as often as that of the *batterie*, and that of the *flambeau* almost as often as the *sirop*, the *propre* alone receives its whole charge at once.

The operator cannot, in any way, fix the quantity of temper that he is obliged to employ, since he does not regulate it by the quantity of feculencies to be separated, but more by the frothy consistence which he is obliged to give them by means of an excess of alkali, in order that the scummer may be able to sustain and

remove them. The necessity of mixing the different charges together in passing them from one boiler to another, makes him never sure of the state of the syrup in any boiler, as it regards the evaporation and temper.

There is never as much alkali put in the *grand* as is considered necessary. When the juice is poured into the *propre*, a small portion of alkali is added; when it reaches the *flambeau*, it again receives another portion, and this ought to suffice. But the signs that are expected in the scum, in the colour of the juice, in the state of the bubbles that the juice forms in boiling, do not always show themselves, or they do not show themselves soon enough, either because the action of the fire is not sufficiently strong, or the feculencies vary in quality and quantity, or, lastly, because the juice is more or less aqueous. Any of these circumstances would severally retard or alter the signs. When the contents of the *batterie* are sufficiently concentrated, it must be emptied, and the *sirop* must immediately supply it anew, and then the *sirop* must borrow again from the *flambeau*, which may be too much or too little tempered. The same inconveniences occur in this boiler, where it is equally difficult to wait for any sign by which judgment can be formed; because it is not known what quantity of syrup is in it, or to what degree of concentration this is brought after the mixture. The signs are again modified and altered by the action of the fire, which is stronger in this boiler. The operator finds himself in uncertainty, and then acts by chance. But, supposing the progressive steps of the work well established, and the alkali accurately apportioned, he would still be very far from attaining the end with which he

should be satisfied; for the temper only separates the feculencies from the juice, and it requires something more to remove them; scumming alone is not sufficient, however carefully it may be practised, and even supposing all the feculencies may be removed by scumming, (which, however, is absolutely impossible,) there still remain the earthy substances, which accidentally get into the juice, such as all the dirt from the boilers and slopes, the dust from the mill, &c.

This process is much more detrimental in proportion to the intensity of the fire, and the richness and good quality of the juice. Because then its concentration in the *batterie* being more rapid, there is less time for removing the feculencies, and for judging whether there is enough alkali; for, in whatever state the syrup may be with respect to the feculencies and the temper, the charge of the *batterie* cannot be deferred; and when once the syrup is there, it is impossible to repair the faults, which are the inevitable consequence of irregularity and negligence.

The necessity of watching over the application of the alkali, of scumming without ceasing, of charging the *batterie* with scarcely any intermission, and the other boilers successively, demands, on the part of the superintendent, a constant attention during the whole time the sugar is being made. But it is impossible to expect that any man can properly fulfil such a task, especially as it is his duty likewise to superintend the work of the mill, the supply of cane trash, and the business attendant on the furnaces and curing houses. It is but natural that the person so placed should be sometimes neglectful, and that he should profit of occasions that may offer, to

rest himself, and slacken his exertions. Some error happens, therefore, daily, on the part of the superintendent or the negroes, independent of those which are inseparable from the progress of the work, and it is particularly during the night that these errors are of most frequent recurrence, and most injurious in their consequences.

It may easily be seen how impossible it is to remedy those faults which are produced from a defect or excess of alkali, or the defective scumming when once the syrup is in the *batterie.* When the expressed juice is poor and of bad quality, a much greater quantity is required to form one boiling; the first quantity with which the *batterie* has been charged, is exposed during three or four hours to the action of the fire, and to the alternation of a greater or less degree of concentration. It may easily be supposed that the action of the fire and this alternation of concentration, continued for several hours, must deteriorate the syrup, and that this injury will be in proportion to the inferiority of its quality. Properly tempered or not, sufficiently scummed or not, when the *batterie* is adequately charged with syrup, it must be concentrated to obtain its essential salt. The concentration is not judged by the degree of heat communicated to the syrup, (which is tried by the finger,) but rather by the granulated consistence which the aggregate of the sugar takes after cooling. Whatever may be the state and quality of the syrup that is about to be evaporated to obtain the raw sugar, the operator always aims at giving it a degree of concentration from which he may be able to obtain it in an aggregate mass, and he is persuaded that the temper well applied will place the syrup in the most proper state for bearing this

degree of heat, but syrup of bad quality cannot attain this end, (notwithstanding the utmost precision in the quantity of temper used,) in consequence of the proportion of mucous juice it contains in the sweet and saccharine state. It is not attempted to obtain the essential salt otherwise than in an aggregate form, and with the intention of bringing it to this state, a degree of heat is communicated to the syrup, (sometimes 250° Fahrenheit, and even higher,) which is stronger in proportion to the bad quality of the syrup. It often happens that the sweet and saccharine mucous juices are decomposed much below this degree of heat. Notwithstanding this, the action of the fire is always continued, although this decomposition may be made apparent by fumes of a white vapour, and by a suffocating smell; the decomposition is sometimes carried so far that the matter inflames. When the concentrated syrup is thrown into the crystallizing vessels, it very quickly takes a solid form, which retains within it all the foul matter extraneous to the sugar. This mass is broken into pieces by iron instruments, and put still warm into the hogsheads. The molasses being more fluid when hot, escapes at first rapidly through all the openings which are left between the crevices of the hogsheads; but these soon become choked up, and the drainings not finding vent, except at the bottom, the process goes on very slowly; because, however fluid the molasses may be, it has then to penetrate a mass of three or four feet in depth. If the original syrup was of good quality, two-thirds, and sometimes three-fourths, of the mass of sugar, with which the hogshead is filled, would be found quite clear of molasses after two or three months drain-

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ing over the cisterns. But if the original syrup was of bad quality, then the sugar would form a clammy mass with the molasses, from which it never could be cleared. The manufacture of clayed sugar, being conducted on the same principles, is open to the same objections.

It is generally acknowledged that, during the homeward voyage, the quantity of molasses which drains from the hogsheads of sugar occasions a loss varying from ten to twenty per cent.;* a loss which cannot be doubted, and which falls entirely on the proprietor, for the merchant never buys raw sugar in the Colonies; this loss is not limited to the voyage, but continues in the warehouses, and even in transporting it to different places for home or foreign consumption; in short, it does not cease till the sugar reaches the refineries, and the hogsheads are emptied.

This is not the only loss which the proprietor suffers. The molasses cisterns being lined with cement, it is very quickly decomposed by the molasses, which soon penetrates through the masonry, and soaks into the ground; though this loss be not visible, it is not the less real, and as the fluidity of molasses is greater than that of oil, it is not difficult to believe that the loss in this

* Dutrone states, that of 120 millions of pounds of raw sugar annually shipped from St. Domingo, only 96 millions of pounds were landed in France. At the same rate, the loss annually experienced by the English planters would amount to the enormous quantity of fifty-two thousand tons of sugar. It would, perhaps, be nearer the truth to estimate this loss at ten per cent. on the quantity shipped, at which rate the annual drainage would amount to beyond twenty-three thousand tons.

way may be very considerable. The raw sugar when arrived in Europe always contains, with some feculencies and earthy matter, a portion more or less of molasses, and, therefore, the European refiners have always found the use of an alkali requisite in refining.

When the sugar for claying is put into the forms to crystallize, there always remains in the aggregate mass, forming the loaf, a portion of syrup, which is to be removed in the operation of claying; but any feculent and earthy solid matters which may be in this mass, protect the syrup from the action of the water, and render the sugar after claying much less pure and white, in proportion to the abundance of these matters. If the sugar is deprived, by judicious treatment, of all insoluble matters, there will be no obstacle in the process of claying to the action of the water, which, after depriving it of all molasses, renders it perfectly pure. All the operations which constitute the arts of making and refining sugar should, therefore, tend towards attaining the greatest possible purity; and when we shall have arrived at that point which it is very possible to reach, the whiteness and brilliancy of the sugar, qualities which are now considered accidental, would then be entirely under our own controul. All the measures which Dutrone proposed and actually put to proof were directed to the attainment of this end. Before giving an account of these, however, he combats an opinion universally adopted, and which tends materially to prevent any improvement in this art, by encouraging the injudicious and excessive use of alkalies. This practice, joined to considerations of economy in fuel, have been the greatest obstacles to

a correct knowledge of the component parts of the juice of the cane, and of the best means of extracting its essential salt.

The necessity for the application of alkali, has been inferred rather from the use which has been so long made of it, than from any careful analysis of the cane juice itself. The cause which required the employment of this substance has been attributed, without due examination, to the existence of an acid in the expressed juice. This idea was eagerly seized, and generally adopted; and has been even considered as fully demonstrated, according to the statements of several chemists, and particularly of Bergman, in his day an eminent Swedish chemist, but who had no opportunity of analysing the juice when recently expressed from the cane.

Although no experiment,* properly conducted, has, therefore, ever indicated the presence of an acid as a constituent part of this juice, yet no one seems to have doubted the existence of a body, without which it has been thought impossible to explain any necessity for the use of alkali. It has been considered that the employment of this agent was necessary to counteract the effects of some acid, to the action of which was attributed all the difficulties that occurred in the manufacture, whe-

* MM. Darcet and Maquer made various experiments, in 1782, at Berci, on the juice of the cane, which M. Boucherie had caused to be conveyed from Malaga, but they were unable to detect the presence of an acid. We have made a great number of experiments in St. Domingo upon the juice of the cane, and are convinced that none gave the smallest evidence of the presence of an acid.—*Dutrone.*

The fact that the juice rather preserves than corrodes copper vessels, is a strong proof in favour of this argument.

ther from the original bad quality of the expressed juice, or from injudicious means, or even from the defective arrangement of those means. This acid was regarded as a formidable enemy, and unremitting attention was bestowed in combating it. One only cause was assigned for all the mischances which arose, and it was thought that there existed only one means of destroying it; and hence all efforts at improvement were circumscribed to seeking out this antidote. Some believed that they had discovered it in quick lime, others in potass, others in soda, whilst some, more minute in their researches, thought they had found it in the ashes of some plants, or in certain neutral salts, such as alum, &c. &c.* All were, however, at one time agreed, that besides the difficulty of finding the proper kind of alkali to neutralize the acid of the juice, it was necessary, when found, to employ it in a proper proportion for the precise neutralising of the acid. This opinion caused the particular kind of alkali to be less insisted upon; and the attention was engrossed in striving to discover certain signs which might fix the point of neutralization of this chimerical aid. This point has for a long time been the object of research. As it was seen that sugar is always

* Mr. Bousie, to whom the assembly of Jamaica gave a thousand pounds for his improvements in the art of sugar-boiling, recommends the use of vegetable alkali, or ashes of wood calcined, such as pimento-tree, dumb-cane, fern-tree, cashew, or logwood as affording a better temper than quick-lime; but he was afterwards sensible that sugar, formed on the basis of fixed alkaline salts never stands the sea unless earth is joined with the salts. Such earth as approaches nearest to that which is the basis of alum would, perhaps, be most proper.—*Edwards's West Indies.*

accompanied by a portion of molasses more or less abundant, and that this molasses cannot be taken away before boiling, it was thought that, after the exact neutralizing of the acid, boiling would unite the sugar in an aggregate mass, the molasses of which would separate much more readily in proportion as this aggregate should be more concentrated. To this state it has always been urged by a strong heat, and the mischief which has ensued in consequence has always been attributed to the employment of the alkalies, either in too small or in too great a proportion.* From this strong persuasion of the existence of an acid as the cause of every obstacle which was presented to the extraction of sugar, the most skilful operators established as principles, that the juice should be tempered with precision in order to neutralize the acid, that the syrup should be evaporated at a very high degree of temperature, in order to separate all the sugar from the molasses, and that it should be highly concentrated in order to produce it in an aggregate mass.

The belief of an acid being contained in the juice, and the hope of finding the means of neutralizing, un-

* Edwards appears fully to participate in this firm persuasion, although he seems as alive as Dutrone to the mischief arising from the use of alkalies. He says, "If there were no redundant acid in cane liquor, lime and other alkali would be hurtful, as may be shown by adding a few grains of alkali to a clear solution of refined sugar, when a precipitation will ensue. I have said that too much temper is perceptible in the sugar both to the smell and taste; it might be added *and also to the sight*. It tinges the liquor first yellow, and, if in excess, turns it to a dark red. Too much temper likewise prevents the molasses from separating from the sugar when it is potted or put in the hogsheads."

der all circumstances, this cause of every difficulty which starts up in the actual operation, has so wholly occupied the minds of many sugar manufacturers, that they have not seen the essential defects attached to the means employed, or those pernicious effects which result from the necessarily irregular process which these means require: while, at the same time, they have entirely neglected to institute any scientific inquiry into the component parts of the juice itself, and of the foreign matters which may accidentally be mixed with it.

When Bergman discovered that the decomposition of sugar by nitric acid produced a particular acid which he called *saccharine acid*, he conjectured, from the extreme affinity of this acid with lime, that the use of this alkali was necessary in sugar houses to neutralize this saccharine acid; a proportion of which he supposed was contained in the expressed juice; this conjecture would naturally arise from his knowledge of the universal use of alkalies in the manufacture of sugar; but he would not have considered this opinion infallible, if, at that time, any one could have furnished him with an exact account of the cane and the nature of its juice.

The belief in the existence of an acid became more confirmed from this discovery of the *saccharine acid*, and the consequent conjectures of Bergman. But the mere opinions, and much less, the errors of a great man, ought not to be put in competition with experience and truth. If Bergman had been able to submit the juice of the cane to a chemical analysis, he would soon have been convinced that the lime decomposes this juice by acting upon its feculencies, but in separating them from the fluid part in the form of flakes, it disadvantageously

takes from them the mucilage which they contain; whence he would have concluded that the only end to be gained from the use of lime and other alkalies was to obtain the entire separation of the feculencies. He would, however, scarcely have failed to observe that if the alkali had the advantages of completely separating the impurities, this is not gained without injury, since, in taking from them the mucilage which they hold in combination, this remains in the juice and becomes injurious to the quality of the sugar.

In this case the merely practical man would have been undeceived as to the extent of the advantages to be derived from the indiscriminate use of alkalies, and would have seen nothing more in them, (under ordinary circumstances,) than the means of separating the feculencies. The defects of the evaporating vessels, and the unfitness of their nature and form, would then have become more obvious; it would have been seen that different juices require each a different treatment, and that the system of considering the successive steps of their progress as not admitting of modification, was highly destructive in a variety of circumstances, and particularly so in the concentration of the juice.

CHAPTER X.

DUTRONE'S METHOD OF EXTRACTING SUGAR FROM CANE JUICE.

The knowledge of the art of sugar making, as it has existed in some Colonies to the present day, may be considered as confined to simply learning the means employed to make it, and in acquiring dexterity in applying these means. A practical branch of science has been thus conducted in mere routine without investigation or inquiry. To be acquainted with the method which is used in the cultivation and cutting of the cane, with the operations performed on the juice and on the sugar which this juice yields, to know how to apply this method, and to perform these operations, as usually conducted, is to know but little, if we continue ignorant of the nature of the cane itself, of the constituent parts of its juice, and of the valuable product which is extracted from it. If we have not some knowledge of the nature and action of the different agents employed, as well in the culture of the cane, as in the manufacture of its juice, if we have not some information on the nature and peculiar properties of the materials and utensils required, and if we

cannot refer the operations, means, and facts to some principle of science which may serve as a basis to the art of manufacturing sugar, we may be assured that we have yet much to learn. It is the study of these different objects, and the knowledge obtained from it, which raise the scientific cultivator and manufacturer above the man of mere routine.

Dutrone expresses his surprise, that although for three centuries the cane had been cultivated in America, there had not been above one or two authors who had written upon the subject. Forty years have passed since he made this remark, and how scanty is the information gathered since that period. His exposure of the errors in the manner of conducting this art, and his method of obviating them, apply almost as well, in some Colonies, to the present day as to the time when he wrote, and we therefore now proceed to give, with some abridgment, his own account of his method.

Some sensible planters, he observes, have been fully aware of the defects of this art, but have only been able to palliate them by augmenting the number of their negroes, in the hope of obtaining more carefulness and regularity.

It is certainly matter for surprise that so little should be generally known of a plant, the products of which have for so long a period formed such important articles in commerce and in domestic consumption, and that its cultivation and the art of manufacturing its juice into sugar, should be so frequently abandoned to the hands of uneducated people; if, indeed, we may dignify by the name of art a process often badly understood, and as often irregularly practiced.

After having examined with the greatest care, and in every possible point of view, the means generally in use in his time, after having minutely and profoundly studied the nature of the cane, and acquired the most intimate knowledge of its juice, he discovered and adopted, what he considered, the most advantageous method for the manufacture of this juice. Many methods seem to have passed in review before him, and many appear to have been rejected, before he ultimately fixed his choice. In this selection he was guided by experience to the adoption of plans in agreement with the soundest principles of chemistry, and appeals to the result as confirming the propriety of his choice.

In the description about to be given, every operation will be shown perfectly distinct; it will be seen that each follows the other without confusion or intermixture; that every step of this method and the order of its progress is simple, easy to be understood, and certain in its execution. It will readily be acknowledged that this progress can be applied to all circumstances under which the juice may be found; that it does not always require the presence of the superintendant; that it may be confided to persons comparatively ignorant without their being able to derange it, and that all the faults which are the inevitable effects of negligence can be repaired with smaller loss than has usually arisen from similar causes.

The juice being composed of solid and fluid parts, united with a very great proportion of water, the first object proposed should be to separate and remove the solid parts. The operations which tend to deprive the juice of all solid matter, both feculent and earthy, is

called clarifying. These substances removed, there remain the water, the mucous juice, and the mucilage, which form together the cane liquor. The next step is to expel by means of heat, the water which is over and above the water of solution; this is evaporation; and the juice is then designated syrup. The feculencies and the superabundant water removed, the water which remains just holds the soluble matter in solution; this is called the water of solution. The object of the work in the last boiler is to remove, by evaporation, a certain proportion of this water; the action of heat upon the water of the syrup is called concentration. It is clearly seen from this, that the manufacture of the expressed juice consists of three principal operations, successive, but very distinct, viz. clarifying the expressed juice into cane liquor, evaporating the cane liquor into syrup, and concentrating the syrup into the state for crystallization.

The clarification is the first and most important work required. Its aim is entirely to disunite and remove the feculencies, and to separate the earthy matters which accidentally fall into the juice. The means employed to decompose the expressed juice and to disunite its feculencies are heat and alkalies; those which should be used to remove them, are scumming, filtration, and time for subsidence.

Heat, in the first moderate ebullition, acts particularly upon the first kind of feculencies, which it separates easily and raises to the surface of the fluid, whence they are removed by a scummer. The second sort require a strong ebullition to separate them. It often happens, especially when the expressed juice is of very good qua-

lity, that heat alone suffices to effect the complete separation of the second kind of feculencies, and although the flakes formed may not always be sufficiently large to be raised by a scummer, it is enough if they are disunited, because then they will not escape filtration and subsidence.*

Alkalies are, in this case, happily dispensed with; an advantage which can never be enjoyed in the usual method in which they must be employed not only to separate the feculencies from the juice, but also to unite them together under the form of a frothy scum, which the scummer may be able to collect and remove with facility. When the feculencies resist heat, it is proper to employ the concomitant action of alkalies. Lime ought always, in all circumstances to be preferred, because in separating the feculencies it takes from them but a comparatively small portion of their mucilage, and when its action does not produce the required effect, which, however, is an extreme case, it should be seconded by that of potass or soda. As the lime, in this method, has only to assist the action of heat in separating the feculencies, it never need be used in so great a proportion as in the usual method, where it is also required to give them a frothy consistence to collect them on the scummer. Whatever care, whatever attention is given in removing the feculencies,

* In some parts of Jamaica, where the cane-liquor was exceedingly rich, Mr. Bousie made very good sugar without a particle of temper. —*Edwards's West Indies.*

In the French Colonies also, where syrup is much used, the cane liquor on some estates granulates so quickly, even without the employment of temper lime, that it is often found difficult to make syrup in the first instance from the cane liquor.

as they gradually rise on the surface, it is impossible to get rid of them entirely by the scummer alone; this is not only insufficient for the feculencies, but it can do nothing for the earthly matters which are accidentally mixed with the juice.

Dutrone was convinced of the absolute impossibility of entirely removing, by the scummer, the impurities belonging to the juice, and the extraneous earthy matters, which are always in a greater or less proportion found in it. He therefore saw that it was absolutely indispensable to filter and to leave the cane-liquor to deposit before concentrating. For this purpose he adapted two reservoirs to communicate with the concentrating vessels which fulfilled this end admirably well, and produced the greatest advantages.

In order that every operation which the manufacture of the juice requires, and the order which it ought to keep, may be easily seen and followed, we will explain the arrangement of the interior of a sugar-house, which Dutrone conceives best qualified for the proper application of this method. All the operations required can be accomplished either by the assistance of one furnace or two separate ones. In the greatest number of plantations one furnace is preferable, because, while it equally well accomplishes the proposed end, it effects economy of fuel and labour. In very large plantations, where the most powerful means are required, two furnaces should be erected, but it will make no difference in the arrangement of the sugar-house. (Plate 2.) The vessels used for boiling are called, collectively, the laboratory, which generally consists of three or four boilers placed in a line. Whatever may be the disposition of the labora-

tory, the order of the work is the same. The laboratory should be placed in the sugar-house in such a manner that its two sides, and the end formed by the concentrating pan, should be isolated through the whole extent, in order that the attendance on them may be easy, and that the negroes may be able to execute, with the greatest economy of time and of means, every thing proper to be done for the greatest perfection of the work. The laboratory (B) in the interior of the sugar-house, (Plate 1, Fig. 1,) has four copper vessels, *(a,b,c,d,)* the capacity of each ought to be from 500 to 600 gallons.* The first, *(a)* which receives the expressed juice, is called the first clarifier, the next *(b)* the second clarifier, the third *(c)* the evaporator, the fourth *(d)* the concentrator. These vessels are placed very near to each other, and have only an edge of two or three inches thickness between them. The masonry in which they are set forms the sides of the laboratory, the least thickness of which, at the upper part, is about fifteen or eighteen inches. The surface of this masonry is inclined seven or eight inches from the outer edge to the lip of the boilers; there are between each of these, basins *(e, e)* let into the masonry, where the scum which is taken off is put, and this is carried back by channels *(f, f)* to the first clarifier:

* Their dimensions are—

	Depth.	Diameter.	
		TOP.	BOTTOM.
a	27 inches.	88 inches.	64 inches.
b	28 „	88 „	64 „
c	29 „	80 „	62 „
d	30 ..	78 ..	60 ..

Their bottoms are slightly convex.

between this vessel and the wall, is a basin, *(g,)* which receives the first feculencies, whence they flow through a pipe *(x)* to a vessel *(h)* placed underneath to receive them. These basins and channels are made of lead, soldered to a setting of copper, which covers the surface of the masonry of the laboratory; this setting is soldered to the circumference of the boilers, which are also soldered to each other; in this state the laboratory offers the best adaptation to the desired end.

It should be remarked, that in the centre of the basins *(e e,)* which are between the evaporator and the concentrator, there is an opening to a canal *(i,)* which descends in the thickness of the masonry, and which is then continued horizontally to the bottom of a copper vessel *(k,)* placed at the foot of the reservoirs for filtration and subsidence. On the surface of the laboratory, on each side of the concentrator, there are canals *(m m)* which proceed from the reservoirs through the brick work, and open *(l l)* near the brim of the boiler. A cooler *(n,)* placed at the end of the concentrator, forms also part of the laboratory. Two reservoirs (E E,) placed at a little distance from the laboratory, serve for filtration and subsidence. The filters ought to be large enough to contain all the expressed juice, (diminished to the state of syrup, indicating twenty-four or twenty-six degrees of the saccharometer,) which the mill can furnish in twenty-four hours. They ought to be made of masonry, lined with lead, and entirely covered with several sieves, the bottoms of which may be made with osier hurdles. There are fixed on these bottoms for the purpose of filtration, first a woollen, then a linen cloth, and lastly a reticulation of brass wire. Two leaden canals

form a communication between the reservoirs and the laboratory, the one *(i)* conveys the evaporated syrup to the vessel *(k)* placed at the foot of each reservoir, from whence it is poured upon the filters, the other, the opening of which at the bottom of the reservoir (E) is shut by a valve *(o,)* carries back the syrup, filtered and subsided, to the concentrator. The bottom of the reservoir for subsidence ought to be raised half an inch above the level of the opening *(l)* of the canal *(m)* near the brim of the concentrator. The sugar-house ought to have two laboratories, and each laboratory ought to communicate with the reservoirs (E E.)* The reservoirs for the expressed juice (F F) are common or proper to each laboratory; they are placed outside the sugar-house as much for cleanliness as for preserving the juice cool. They ought to be covered by a well-enclosed shed, or vaulted over. These reservoirs, lined with lead, should be each large enough to contain three hundred and seventy-five gallons at the least. They ought to be always filled to a fixed and determinate height, equal to one charge,† in order that not only an exact account may be kept of the quantity of expressed juice which comes to the sugar-house, but also of the quantity of lime that should be employed to separate the feculencies from the juice. As it is highly proper to know the degree of richness of the juice to be manufactured, there should

* It is always better to have two fire places, though only one should be used at a time, lest any accident should happen to the one in use. This precaution is more necessary, since, as the canes cannot be kept without fermenting, all those which were cut would be lost.

† The charge must be a determinate quantity, which ought never to vary when once fixed.

be a saccharometer to ascertain it from time to time. When all is properly prepared for each operation, and the reservoirs for the expressed juice are filled with a known and fixed quantity, it is made to flow into the first clarifier. The proportion of quick lime, for separating the feculencies, should be immediately ascertained. For this purpose an hydraulic balance should be used; this was invented by an Englishman, and introduced two or three years ago into St. Domingo (1789.) This balance, which is very ingenious, serves to show the quantity of feculencies which exist in the expressed juice and the quantity of lime necessary to separate them. Although it may not rigorously indicate what is the necessary quantity for the complete clarifying, it is, however, very useful in determining the quantity of lime which ought to be employed in the first instance. Its use is extremely safe, as the proportion of lime which it indicates is never in excess. The lime thus weighed is put into the juice with which the first clarifier is filled. That its action may take place at the same time over all the juice, great care is taken to spread it by agitation for a minute or two with a ladle; then it is poured entirely into the concentrator; after having filled all the boilers with a charge thus tempered, heat is applied. The coppers, of course, receive a degree of heat relatively to their proximity to the fire place. The juice of the concentrator, therefore, is the first whose feculencies separate; the action of the heat proceeds successively through the boilers. The first feculencies are removed by the scummer from each of the boilers as fast as they rise to the surface of the fluid; they are poured into wooden buckets and carried to their place of destination (*h.*)

Those of the first clarifier are poured into the basin *(g)* which is between it and the wall, from whence they flow out into the vessel *(h)* placed there to receive them. The impurities of the second sort are poured into the little basins *(c e)* on the surface of the laboratory. The juice, which is unavoidably removed with them in scumming, carries them through the channels into the first clarifier, where they are again removed with the scummings of this copper. The scum is taken off as fast as it is produced, and to each charge, if it be thought necessary, lime in substance, or lime-water, or some other alkali is added. When the syrup of the concentrator indicates twenty-two or twenty-four degrees of the saccharometer, the fire is damped and the syrup is laded into the basin *(e)* which communicates with the vessel *(k.)* Immediately after having emptied the concentrator it is filled again with the *entire* charge of the evaporator, the heat is continued and the contents of each copper pass successively from one to the other till they reach the evaporator, leaving the first clarifier empty, and this is immediately supplied with a fresh accession of juice. In the meantime, as fast as the cane-liquor reaches the vessel *(k,)* placed at the foot of the reservoir (E,) it is poured upon the filters, and falls into the reservoir freed from the solid matter which it contained. The scumming and evaporation are continued; the contents of one copper are passed successively into another, the syrup in the concentrator is passed into the vessel *(k)* and thence into the reservoir for subsidence, till this is filled. The different steps of the work should be so disposed, that the first reservoir for subsidence should be filled about six or eight o'clock in the evening. Then

the syrup, always evaporated to the same degree, is conveyed in the same manner to the second reservoir, by the canal which communicates with it, and this work is continued through the night.* Towards five or six o'clock in the morning the fire is damped and the concentrator is emptied; after well washing it, if required, the valve of the first reservoir is raised, the filtered cane-liquor runs perfectly pure into the concentrator, having deposited, during eight or ten hours of perfect rest, the feculent and earthy particles, which, owing to their extreme fineness had passed through the filters.†

When the concentrator is charged by this means with a quantity of syrup suitable for making a boiling, the

* The system of night working, which used to be very general throughout the Islands, is now much less frequently resorted to, and on some plantations, where the means of the proprietor enable him to provide the most improved mills and machinery, night working is entirely unknown. On estates where it is still found necessary, during the hurry of the crop, to continue working during the twenty-four hours, this duty is made as light as possible to the negroes, who are divided for this purpose, into two gangs or *spells*, each of which spells is subdivided into two parts, one taking the first, and the other the last half of the night; by which means, the night labour of each negro is reduced to eighteen hours in the week.

† Monsieur Bonmatin gave an account, in the year 1814, of his method of extracting sugar from beet root; which appeared to the French government to have so much importance, that they caused it to be printed and distributed in those departments where that branch of manufacture was followed. In this account, Monsieur Bonmatin states, as one part of his process, that after the evaporation of the juice to the state of syrup, as indicated by 32° of Baumé's saccharometer, and before its concentration, to obtain crystalline sugar, he allows the syrup to rest during four days, in order that all the foreign matters which it contains may subside.

valve is shut and it is ascertained whether the clarifying is well and perfectly done. For this purpose some syrup is taken in a silver spoon and inspected in different points of view, in order to ascertain that it contains nothing perceptible to the eye. Some drops of lime-water are poured into this syrup which should appear very clear and transparent, and it is then examined anew.

If after one or two minutes no solid particles are perceived to swim in the liquor, we may be assured that the clarifying is complete. Heat is then applied to finish the evaporation and concentration. If the syrup is suspected to be of bad or middling quality, then a test of caustic-alkali, well filtered and mixed with lime-water, must be employed. If the action of these agents causes the appearance of any flakes of feculent matter, then a temper of lime, or other alkali, is put into the syrup in proportions regulated by the quantity of the flakes, which in this case are always very trifling. They are soon separated by the concurrent action of the temper and heat which raises them to the surface, whence they are easily removed by the scummer. When the colour of the syrup is a very deep brown, and lime-water and alkalies fail to separate any feculencies, it may be presumed that its darkness is in part owing to an excess of temper, which holds the mucilage, and sometimes, also, a portion of the second feculencies in solution. In this case very diluted sulphuric or oxalic acid may be used as a test, for, if the alkali is in excess, either of these acids will precipitate it in the form of a neutral salt, and the acid will also affect the colouring part of the mucilage; the base of this juice is then precipitated in the form of white flakes, and any portion of the second kind of fe-

culencies which the alkali may have held in solution, is likewise precipitated. To remedy this excess of alkali, very diluted sulphuric acid, or cream of tartar, citric acid, or oxalic acid may be used. But to employ these different acids with success, a person must be well acquainted with their properties. They may, however, be dispensed with in the method we are now explaining, by being careful to procure good lime and weighing it with accuracy. While the charge of the concentrator, and all the contents successively, of the first reservoir, are being concentrated, scumming and evaporating are continued in the three preceding coppers, and the syrup of the evaporator, after being carried to the proper point of concentration, is passed from this copper to the second reservoir, always through the little basin *(e)* and the canal *(i,)* which communicates with it; this reservoir continues to be thus filled, (always previously passing the syrup through the filters,) till all the contents of the first reservoir are concentrated: this ought to happen at about six or eight o'clock in the evening, at this moment the charge of the evaporator is passed into the concentrator, which is again converted into an evaporator.

If it is requisite, the first reservoir for subsidence is washed, and then it is filled anew as at first, with the syrup evaporated in the concentrator to the proper fixed point. The second reservoir is left to subside during the night, and at five o'clock in the morning the boiling of the syrup from this reservoir is begun similarly to that from the first reservoir on the preceding day. This order once established, it continues always in the same alternation. Thus in this work each charge of expressed

juice passes from one copper to another without being mixed, and receives, successively, the degrees of heat most proper for its different stages of clarification and evaporation. The temper of each charge can be regulated according to the signs presented by the scum and to the bubbles formed in ebullition, &c. but to these signs implicit confidence must not always be attached. All the solid matters which have escaped the scummer are most successfully removed by the filtration and subsidence to which the syrup is subjected without any increase of labour, since the progress of this method does not require a greater number of negroes than is ordinarily employed in the usual method. The clarifying and evaporating begin almost at the same time, and advance together to the reservoirs for subsidence, where the clarifying is entirely finished. The action of heat upon the feculencies ought to be moderate, a too slow or too rapid heat are both injurious. In these coppers it can be graduated at will, the shape and material being favourable for this desired effect. When once the power of the furnace is known, the charge of the clarifier can be regulated accordingly, by augmenting or diminishing the quantity of the expressed juice in such a manner that it may arrive at the desired point of clarification in the required time.

The syrup is never evaporated to such a density as in any way to injure or obstruct the separation and removal of the feculencies by the scummer. The charge of the first clarifier being from 250 to 370 gallons of juice, and this charge passing entire from one copper to another, the proportion of water which the cane-liquor contains is always great enough to allow free scope to the fecu-

lencies to separate and be disengaged by the scummer; for however rapid the evaporation may be, its progress can be regulated at will to the fixed point for filtration and subsidence.* This point is ascertained by the saccharometer, an instrument formed of a bulb of copper, two or three inches in diameter, attached to a tube six or eight inches in length. This saccharometer is charged with grains of lead adjusted in such a manner, that, at the 24th degree of Baumé's scale, the bulb plunged in the fluid would be just covered to the commencement of the tube. The negro boiler being made acquainted with this point, is charged to watch the work; it may with safety be abandoned during the night to his guidance, as the concentrating only takes place during the day; the negroes have nothing more to do than to weigh the lime for each charge of the expressed juice, which is put into the clarifier, then to scum and pour the cane-liquor on the filters. The progress in the usual method with iron boilers has none of these advantages; on the contrary, they have the opposite defects.

After the account we have given of the progress of clarifying, evaporating, and concentrating in the laboratory, with the four copper boilers, (Pl. 1, fig. B,) it is easily perceived that when these three operations in the laboratory are pursued as it is proposed, the different steps of the work will, although divided, be absolutely the same. The concentration performed in a single vessel over one fire, or in the laboratory with a double fur-

* The rapidity of the evaporation can constantly be ascertained by reference to the Table, page 81; that, connected with the use of the saccharometer, should regulate the progress.

nace, (Pl. 2, fig. 1,) will not in any way be different in its execution to that in a laboratory with four coppers. It will only require the attendance of a few more negroes, but in a large plantation it is essential that the work should be performed very rapidly, and therefore its steps should be more divided.

The cane liquor being now entirely deprived of all solid matters by the means just described, it can be concentrated to the required point; its state being fully ascertained before concentration, and the defect, (if any,) in alkali being easily remedied.

The advantage of concentrating only during the day is very important, as the overseer can thus bestow his attention and care upon the concentration of the whole without being obliged to watch all night; the operations during this period being reduced to those of clarifying and evaporating, may safely be entrusted to the negro commander, or head boiler, who is one of the most trustworthy persons on the plantation.

The proportion of essential salt which the cane liquor contains cannot by any means be augmented; the sweet and saccharine mucous juices cannot be converted into sugar; nor can the former and the mucilage be removed before the complete concentration of the syrup, since those juices are more soluble than the essential salt. The end proposed then, is to extract the greatest possible quantity of this salt in the best possible state. For this purpose we must borrow the aid of chemistry, the principles of which are much more required in the concentration and crystallization of middling and bad syrup, than in that of good quality. The sweet and saccharine mucous juices cannot support nearly as high degrees of heat as the essential salt. They are immediately decom-

posed by the application of degrees of heat which may safely be used to syrup of good quality. The business of concentration, as we have before observed, is the action of heat upon the water of solution of the sugar. The sugar boilers, both of America and Europe, have rarely had a just conception of the action of heat in the operation of concentration. Their knowledge has generally been confined to some terms which serve to designate the particular state in which the syrup under concentration is found. The recollection of these terms too often makes up the whole science of the sugar boiler.

Concentration being the action of heat upon the water of solution, ought necessarily to begin and terminate at fixed degrees of the thermometer. The truth of this position Dutrone affirms to have been demonstrated to him by multiplied experiments made with solutions of sugar refined to a state of perfect purity, and to which he applied the action of heat at each degree, commencing at 83° and ending at 110° of Reaumur. This scale is not in use in England or her Colonies, and therefore in the following Table we have added another column with the corresponding degrees in the scale of Fahrenheit.

Each of the experiments was made with a solution of one hundred pounds of sugar in sixty pounds of water. When the degree of heat indicated by the thermometer is ascertained, a reference to this table will show at one glance what proportion of the water of solution has been evaporated, what quantity of sugar is thereby rendered capable of passing to the solid state, and how much water is yet to be evaporated before the remainder of the sugar can be crystallized. If, for example, during the process of concentration, the thermometer rises to 230° Fahrenheit, or 88° Reaumur, this table informs us that

31 lbs. 3 oz. 4 dr. of water have been evaporated, that 52 lbs. of sugar have thereby been rendered capable of crystallizing, and that 28 lbs. 12 oz. 12 dr. of water remain to be evaporated, before the remainder of the sugar, 48 lbs. can assume the solid form.

TABLE

Of the action of heat upon a saturated solution of sugar, commencing at the point of saturation, and terminating at the point of perfect crystallization.

Degrees of thermometer.		Water of solution evaporated at each degree.			Product of crystallized Sugar at each degree.			Water which remains combined to the sugar in the state of syrup, after the crystallization, at each degree.			Sugar which remains combined with the water in the state of syrup at each degree.		
Fahrenheit.	Reaumur.	lbs.	oz.	dr.	lbs.	oz.	dr	lbs.	oz.	dr.	lbs.	oz.	dr
219	83	0			0			60			100		
221	84	4	12	14	8			55	3	2	92		
223	85	11	8	14	19	4		48	7	2	80	12	
225.5	86	18			30			42			70		
228	87	24	9	10	41			35	6	6	59		
230	88	31	3	4	52			28	12	12	48		
232	89	33	11	10	56			26	4	6	44		
234.5	90	36	3		60	5		23	13		39	11	
237	91	38	1		63	4		21	15		36	12	
239	92	39	4		66	3		20	12		33	13	
241	93	41	7	10	69	2		18	8	6	30	14	
243.5	94	43	4		72	1		16	12		27	15	
246	95	45			75			15			25		
248	96	46	7	4	77	7		13	8	12	22	9	
250	97	48	7	8	80	5		11	8	8	19	11	
252.5	98	50	1	10	83	3		9	14	6	16	13	
255	99	51			85			9			15		
257	100	52	5	14	87	4		7	10	2	12	12	
259	101	53	1	6	88	6		6	14	10	11	10	
261.5	102	54	1		90	1		5	15		9	15	
264	103	55	3	10	91	4		4	12	6	8	12	
266	104	55	12		92	7		4	4		7	9	
268	105	56	7	10	94	2		3	8	6	5	14	
270.5	106	57	3	8	95	5		2	12	8	4	11	
273	107	58	6	8	97			1	9	8	3		
275	108	58	14	8	98	2		1	1	8	1	14	
277	109	59	7	10	99	2			8	6		14	
279.5	110	60			100								

Although soluble matters other than the essential salt are combined with the water of solution, the water is, nevertheless, always united with it in a relative and determinate proportion. The thermometer ought therefore to be employed to determine its concentration, the solid product having always relation to the proportion of water which the heat has evaporated at each degree of this instrument. If the extraneous matters exist in a greater abundance, the quantity of pure sugar will be less than that marked in the foregoing Table.

The use of the thermometer in concentration, far from excluding the proof of the finger, which is very convenient, serves, on the contrary, to render its practice less equivocal, giving to the operator fixed rules by which he may more safely be guided.

Syrup, when concentrated beyond the point of solution, assumes, in cooling, the crystalline form. Experience shows us that the molecules of similar bodies, in taking this form, require to move freely in the fluid which holds them in solution, in order to their exercising upon each other their mutual attraction. These molecules take in their union a form much more regular in proportion as the water in which they unite themselves is more considerable. When the mother water exists in a great proportion compared to the sugar which is to be crystallized, very large and regular crystals are formed; in this state it is called sugar-candy.* We know that salts are much more pure and perfect as the

* Crystallizing in a great quantity of water should not be confounded with crystallizing in a great mass, as a planter of St. Domingo did, who had a crystallizing vessel made twenty feet long, ten

forms they make approach nearer to those which nature has assigned to them. Sugar-candy is in the most perfect state that can be desired, and the means that it is proper to employ to extract the essential salt of the cane, ought, therefore, to be founded on this principle of chemistry;—*to crystallize in a considerable quantity of water*, a principle fully ascertained and established for all bodies which crystallize in cooling.

The concentration of syrup should always be conducted on this principle; the vessels in which the sugar is put to crystallize ought to have the most favourable form and capacity given to them for crystallizing and draining it.

The curing house on the plan under consideration must first be described. The buildings for the curing house (Plate 1, E, F) ought to be very large and built on the same line, to save labour, and that every thing which is passing in them may be seen at one view. There are several rows of vessels for crystallizing, (Plate 1, H. I) placed upon channels (K) which terminate in the cisterns, (L, M, N, O.)

These vessels ought all to have the same form and capacity. A certain number (H) are selected to receive the concentrated syrup, and the channels on which they are placed have their particular cistern. Other vessels are set apart to receive the first concentrated syrups, as will be hereafter explained, and their channels should have a particular cistern. The second, third, and fourth concentrated syrups ought also to have their own cisterns,

feet wide, and two deep; the crystallization of sugar with a proportionate large quantity of water can be performed in the smallest vessels.

in order that the products in sugar and syrup should never be mixed, and that they may be treated separately.

Dutrone found by experiment and experience that the quantity of matter which unites the most favourable number of circumstances for crystallizing the essential salt of the cane juice, is from fifteen to sixteen cubic feet; and it was from this knowledge that he regulated the form and dimensions of the cases about to be described. He made many trials of cases differently shaped at bottom, and he arrived at the conclusion that those upon which he ultimately fixed are most effective and convenient. (Plate 1, fig. 6, 7.) The crystallizing case (H, I) ought to be five feet long and three feet wide. Its bottom is formed of two planes inclined six inches (*d, d,* fig. 6,) the meeting of which forms a channel, and which is the central line of the greatest dimensions, there are in this channel twelve or fifteen holes of an inch in diameter for the syrup to drain through; the depth of the case is nine inches at the side, increasing towards the channel where it is fifteen inches. This case ought to be made of planks of wood of an inch thick, and lined with very thin sheets of lead. It is better before lining the case to pierce the holes of the channel, and to burn the inner circumference of these holes with a ball of hot iron, in such a manner that there should be a slight concavity in the middle of each; by this disposition not a drop of syrup would remain in the cases after curing. The holes are bound with tinned copper rings soldered inside to the lining, and folded down outside, and nailed to the bottom. The case thus made and lined with care, offers every possible advantage for crystallizing and draining.

These cases are placed upon cross pieces *(a, a)* fixed on and supported by little posts, *(b, b,* Fig. 6,) eight or ten inches from the ground. The cross pieces are made of planks, three inches wide and two inches thick, sawn in proper lengths. They are nailed and fixed ten inches from the central line of the gutter or channel to which they run parallel. The channels (K) upon which they are fixed are made of masonry, and incline towards the cistern which receives the syrup; they ought to be cemented and lined with sheet lead; though they are inclined, the cross pieces should be on a horizontal level plane. The syrup cisterns, (K, M, N,) situated at the extremity of the channels are dug several feet deep, cemented and lined with lead, and placed as near as possible to the refineries. Their capacity ought to be very nearly the half of the aggregate capacity of the cases, whose syrup they are to receive. They are covered with planks of two or three inches deep, even with the ground, and have an opening (R) like a trap-door, which communicates with the refinery.

The concentration of the syrup is regulated by the thermometer; the most favourable degree for obtaining the essential salt crystallized in the greatest proportion, and in the finest and most regular crystals, is 87.5° to 88° Reaumur, (229° to 230° Fahrenheit.) When the proper degree of concentration is ascertained, the fire is extinguished; then, without running any risk of burning the sugar, the contents of the concentrator are emptied into the cooler (*n*,) which forms part of the laboratory; from thence it is immediately put into the cases; care must be taken to stop up the holes of these with wooden pegs, (Fig. 6, *c*, *c*,) and maize-stalks bound

round them. Attention must also be paid to put a little quantity of sugar about each of the pegs, the points of which rise two or three inches on the inside; a little of the syrup is poured upon this, which quickly growing cold, acts as a cement in keeping in the pegs. The cases perform the office of a second cooler; they are filled from two different boilings, which are mixed well together as the second is poured in. The matter thus put in the case cools slowly, and after twenty-four hours, the crystillization is found to have taken place at the surface, the sides, and bottom; it is better then to give a slight movement to all the mass still fluid with a wooden stirrer, taking care to raise towards the surface the crystals which have already settled at the bottom; after this operation, the crystallization goes on simultaneously in all parts of the case, and if this agitation has been given in time, and has been well extended, the crystallization in five or six hours becomes general and equal from the top to the bottom. After four or five days the whole mass being cold, it is right to draw the pegs, then the draining takes place very quickly, and in six or eight days it is entirely completed. The sugar well drained of its syrup, is slightly moist, but after being exposed to the air it becomes perfectly dry. In this state it should be packed in hogsheads, where it must be pulverized like clayed sugar. In concentrating the syrup at 88° Reaumur, (230° Fahrenheit,) half, and even more of the quantity of sugar it contains is obtained, and if the clarifying and crystallizing have been well conducted, this sugar is then in the highest degree of purity and beauty that raw sugar can possibly acquire. If the sugar from the syrup is to be

clayed, it is then to be put to crystallize, either in the cases we have just described or in forms. When cases are employed, the degree of heat must be rather increased and raised from 88° Reaumur (230° Fahrenheit) to 90° Reaumur (234° Fahrenheit.) The agitation necessary to be given to the matter while crystallizing must likewise be watched over with the greatest care. When the forms are employed it is better to dispose a part of the curing house in compartments, in the same manner as the usual method. A second cooler of copper must be fixed of 120 to 200 gallons capacity, in which three or four boilings should be united, with which the forms are filled, and the rest of the work proceeds in the manner already described. The forms cannot be used but when the syrup is of good quality, on account of the degree of heat (234° or 238° Fahrenheit) that their capacity and conic form require. Syrup of middling or bad quality cannot bear that heat, and then it is better to have recourse to the cases as suitable for the crystallization of sugar that can be extracted from all sorts of syrup. It ought to be observed here, that the syrup having been deprived of all solid matters, no difficulties present themselves in the crystallizing, curing, claying, and stoving the essential salt, and after having undergone these various operations, the sugar is perfectly pure and as white as can be desired.

The syrup, separated from the sugar in draining, was called by Dutrone *syrup of vesou*, to distinguish it from all the other sorts of syrup. The syrup of vesou is again to be distinguished into first, second, third, &c.

We will now describe the arrangement of the laboratory which is to clarify and concentrate the syrup of

vesou. In a little building, (Plate 1, Fig. 5, G,) called the refinery, adjacent to the curing house, there are a furnace and one copper *(f)* placed near the centre to concentrate (and clarify if necessary) the syrup. The setting of the boiler is fifteen or eighteen inches thick in the upper part of its circumference; its surface forms an inclined plane of five or six inches from the external edge to that of the boiler, where a setting of copper or lead is soldered, which covers it entirely; upon the sides of the laboratory are two little basins, *(g g,)* which receive the syrup as it is to be concentrated; they serve also for filtration when it is necessary to clarify it. These basins are made of masonry and lined with lead; their bottom is at the height of the brim of the boiler, in which they empty themselves by a little tube *(h.)* There ought to be placed on the sides of the refinery a channel *(i)* to convey to the basins the syrup of vesou, which is poured into a small receptacle *(k)* placed at the extremity of this channel, from the syrup reservoir, close to which it is placed for that purpose.

Much more syrup of vesou can be concentrated in this one boiler than with the two by the old method. As soon as it is charged with the proper quantity of syrup, heat is applied; while the concentration is going forward, the basins which are at its sides are filled, ready to supply it anew, with every possible rapidity, at the very instant after it has been emptied.

When the syrup of vesou is of good quality, the degree of heat is carried to 88° Reaumur, (230° Fahrenheit.) The requisite degree of concentration is ascertained by the thermometer, as well as by the proof of the finger. The fire is then damped, and the contents

of the boiler emptied into the cooler *(l,)* fixed near it for that purpose. The tube connecting the boiler with the side basins is then instantly unstopped, the syrup flows into the boiler, and the fire is resumed. This order once established is always continued in the same manner. The first boiling is put into the cases, and that which follows is soon joined to and well mixed with it. All the following boilings are similarly blended two and two, and left during twenty-four hours, and sometimes longer. At this period, the cooling being at a proper point, which is tried by the finger, the contents of the cases are stirred, and treated as before described, but it requires to drain a few days longer than the first made sugar; it is then turned out, and proves extremely pure and fine.

The syrup of vesou of the second, third, fourth, and fifth products are concentrated in the same manner, but with a degree of heat which should be diminished proportionally with the inferiority of their quality. The first boiling is divided between all the cases which are to be filled, and so on of all the succeeding boilings. The draining of the sugar from the syrup of vesou of the third, fourth, and fifth products, requires fifteen or twenty days for completion; after which the sugar extracted from the syrup of each product is put separately into hogsheads.

At the time when the copper is charged with syrup of vesou for concentration, some lime-water is added proportionate to the quality of the syrup. When it is very bad, or when the syrups are the fourth and fifth, it is perhaps better to increase the alkaline properties of the lime-water with potass.

After all these repeated boilings and crystallizations, a residue still remains, called the molasses of vesou.

It has been shown that syrup of the best quality always contains a portion of mucilage, while that of middling and bad quality, in addition to this mucilage, contains a greater or less proportion of sweet and saccharine mucous juices. Now it is evident that, in the various boilings and crystallizations which the syrup has to undergo, the proportion of these juices bears an inverse ratio to the essential salt, or as the proportion of the one diminishes, that of the other increases; but, provided the concentration were well conducted, syrup of good quality would give, in a crystalline form, all the essential salt it contains, less a small portion which is found at the last entangled with the mucilage, and the residue of syrup of middling or bad quality will be proportionate to the sum of the mucilage and the sweet and saccharine mucous juices, and to the essential salt which these juices retain entangled in them. These becoming more concentrated at each crystallization, at length are quite viscid, and oppose by their tenacity a greater resistance to the union of the saccharine particles. It has been seen that alkalies enter into perfect combination with the mucilage; they equally combine with the sweet and saccharine mucous juices, which they render much more fluid. This property is the reason why alkalies are used in boiling syrup of every kind; for then the saccharine particles, finding less obstacle in uniting, crystallize better in proportion as these juices are rendered more fluid by their union with alkalies, the action of which, aided by that of heat, having also a pernicious effect upon the constituent principles of the essential

salt, decompose it, and increase the proportion of molasses.

It is now easily perceived that the molasses is composed of sweet and saccharine mucous juices, mucilage, a part of the sugar decomposed by the concurrence of heat and alkalies, and of a portion of this sugar entangled in all these matters.

If the molasses is reduced to a consistence, indicated by forty degrees of the saccharometer, and if it is left for a long time in a large shallow cistern, the saccharine particles will, notwithstanding the resistance which the molasses opposes to them, gradually unite with each other under a crystalline form, and fall to the bottom of the cistern. This fact is proved in every Colonial sugar house.

If a solution of oxalic acid is poured on molasses diluted with distilled water, this acid will not only unite itself with and precipitate lime, but it will also take away the colouring principle of the mucilage, the base of which will appear under the form of little white flakes.

It will be seen by the Table, p. 81, that water united to sugar is at the point of saturation in the proportion of three parts of water to five parts of sugar, which is indicated at a temperature of 22° Reaumur, (81.5° Fahrenheit,) by 34° of the saccharometer. It is easy to conceive that the mucilage, &c. which are found united to the sugar in this solution, add to the specific gravity of the syrup in proportion as these juices preponderate; whence it may be concluded that syrups which indicate the highest degree of the saccharometer beyond the term 34° are the worst. This instrument should, therefore, serve to denote the quality of syrups.

To complete the description of Dutrone's method, we will give a slight sketch of the furnace constructed by him. He seems to have very excellent views on this subject, and investigates it with that knowledge of first principles which he so eminently shows in all his reasonings. The construction of furnaces is, however, better understood in the present day, and his plan may, perhaps, be somewhat simplified and improved. In the course of his work, he very much contemns the practice of using one furnace to several boilers, but still adopts this pernicious system on account of its economy in fuel. In the old Colonies, many substances must be used as fuel which would otherwise be converted into manure, and this plan of using but one furnace to several boilers has been, in a manner, forced upon planters by the necessity for lessening, by every possible means, the consumption of fuel. This, however, is an arrangement which should be invariably avoided, in all cases where wood for fuel can be had at a moderate expense, or where coal can be cheaply imported. Dutrone describes simple furnaces with only one evaporating pan, (Plate 1, Fig. 5;) compound furnaces with several, to which the heat is applied by means of a flue, (Plate 1, Fig. 1, B;) and double-compound, which are several furnaces, having only one chimney for all, and which can be used either together or separately, (Plate 2, Fig. 1.)

We will merely speak of the second one which is used with the boilers, particularly described in his method.

The ash-pit, (Plate 2, Fig. 2, D) is nearly circular. There are several openings to this; one, (*a*, Fig. 4,) by which the cinders are removed; this is made low down that the cinders may prevent the access of air through

Plate

Fig. 3.

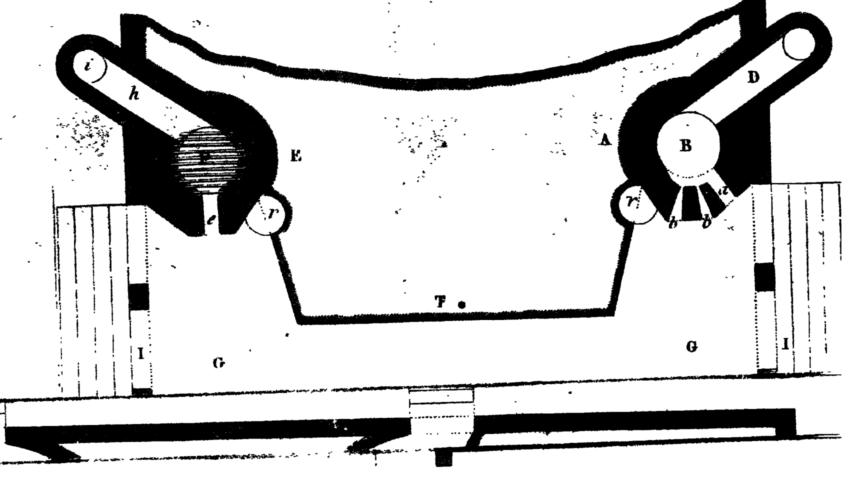
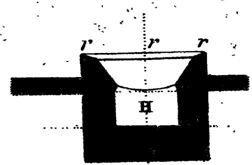


Fig. 5.



it; the others, (*b*, *b*, Fig. 2,) are air holes for the access of air proper to support combustion; these holes should be much larger externally than internally, as it is found that they then better serve the purpose of bellows.

The ash-pit is terminated by fire bars, not more than three inches wide, and three or four inches apart from each other; if they are wider or nearer to each other, there cannot be a sufficient supply of air for the purpose of combustion.

In the fire-place there are one or two openings (*d*, *d*,) which are formed by cast iron cylinders of twelve or fifteen inches in diameter. The flue (H, H) is upon the masonry (E, E;) it is an irregular cavity, so arranged that the boilers above shall receive as much, while the brick work shall absorb as little heat as possible. This flue decreases in size till it reaches the chimney, (I, K, Fig. 2 and 4.) The masonry of the furnace is very solid, the inner part (*e*, *e*) is made with fire bricks, and the outer part of calcareous stones and flints in preference to brick, they being worse conductors of heat.

After giving a long account of the furnace on his plan, and that on the old system, and furnishing the particular dimensions of each part, Dutrone proceeds to draw a parallel between the two: we will content ourselves with giving the result.

The capacity of the fire-place and the flue of the furnace, with the iron boilers, is 1274 cubic feet. That of the furnace, with the copper boilers, is 320 cubic feet, the latter being to the former in the proportion of one to four.

Although the iron boilers present so much greater fire surface, yet, when their elliptic shape is considered,

it will be seen how much heat is wasted and misapplied. As heat acts with its principal effect in a perpendicular direction, its force is reflected and thrown back by the oblique surface of elliptic boilers, while their shape necessarily occasions a great space of masonry between each to be subjected to the action of the heat, thereby wasting much fuel. The fire playing on an elliptic surface will not produce more effect than if its upper area, or a circle of the diameter of the vessel, deducting the part taken up in the setting, were exposed to its direct influence.

The dimensions of the five iron boilers, called by the French *La batterie*, &c. are,

	Diameter.		Surface.		Area.
First .	44 inches	Allowing four inches for setting.	18 feet	4 inches	8.108
Second	48 do.		21 do.	12 do.	10.80
Third .	52 do.		24 do.	24 do.	12.84
Fourth	56 do.		29 do.	92 do.	14.107
Fifth .	60 do.		34 do.	16 do.	17.15
	Total		127 feet		64

The dimensions of the copper boilers, described by Dutrone, are,

	Diameter.	Area.
First	60 inches .	19 feet 91 inches
Second	62 do. .	. 21 do. – do.
Third	64 do. . .	22 do. 49 do.
Fourth	64 do.	22 do. 49 do.
	Total . . .	85 feet 45 inches.

The latter, therefore, present effective fire surface in proportion to the former, [illegible] are to three, and, sup-

posing equality of circumstances, would evaporate much quicker; but they bear a still greater advantage in the superior construction of the furnace by which the caloric is much more economically applied.

These observations and proofs of the ill adaptation of elliptic vessels have been thus given in detail, since this shape is generally continued to the present time. We are aware that the merits of Dutrone's system are freely acknowledged by many intelligent French planters, and that, in some cases, this has been introduced where the means of the planter have been adequate. That, at the time he wrote, his improvements were not more generally adopted, arose chiefly from political causes: the convulsions to which the government of the parent country was exposed, having brought to a state of jeopardy or ruin, capital employed in agricultural pursuits in the French Colonies.

CHAPTER XI.

COMPARISON BETWEEN THE OLD FRENCH METHOD AND DUTRONE'S IMPROVEMENTS.

DUTRONE next proceeds to draw, at great length, a parallel between his own method and the one usually practised at the time he wrote; it would not be doing justice to his judicious arrangements entirely to pass over this comparison. The defects of the method pursued in St. Domingo at the time he wrote have been so fully pointed out in the ninth Chapter, that we will not detain our readers with dwelling or enlarging further upon them, but proceed to give the substance of his reasons for finding advantage in the employment of the method which he has proposed.

If it be objected that the quantity of work performed is not as considerable during the night, since only the operations of clarifying and evaporating are then attended to, it can be shown, that the advantages of this arrangement very much outweigh this objection; the work goes on in a regular uninterrupted course, unimpeded by accidents which so often arrest the progress, as well as injure the manufacture, when the ordinary system is pursued.

The reservoirs for filtering and subsidence, without increasing the labour, render the manufacturer master of all his operations; there is no necessity for using any more alkali than exactly suffices to separate the feculencies. In passing the syrup from one copper to another, the boiler can examine and act upon the indications which should guide him in the employment of the alkalies. He can also direct the progress of the evaporation according to his wish by the use of the saccharometer, and he is certain of completely removing all the insoluble matters by filtration and subsidence. This reservoir, in which the syrup is left to subside, affords to the superintendent the great advantage of concentrating the syrup only during the day. Thus, without the fatigue of night watching, he can always give his personal attention to this last important process. He can discover and remedy any faults, which may have been made in the use of the alkalies. He can, by various means, of which he should know how to avail himself, add to the purity of the syrup about to be concentrated. He has the advantage of beginning the concentration with a given quantity, and continuing it without any interruption from the access of fresh syrup. Lastly, he will find in the thermometer a sure and infallible guide in regulating the different degrees of heat, and in ascertaining the point of sufficient concentration; and then the fire being damped, he can pour off the syrup without decomposing a particle of sugar.

This method of concentrating the syrup and crystallizing its essential salt appears to have great advantages, which extend equally over every quality of juice that may be acted upon. It is in general thought adviseable to concentrate the syrup highly, with the idea of bring-

ing all the saccharine particles closer together, that they may the better form a hard compact aggregate mass, free from molasses. This is sought to be effected by the excessive application of heat, which decomposes the sugar and does infinite mischief.

By evaporating almost all the water of solution at the first and only boiling, the crystallized particles take a solid form as soon as the heat abandons them; but not having time to unite in great number, or to acquire in their too sudden union the form which nature has assigned to them, and which they always take when the union of their particles has been slow and free, they form little irregular crystals, minute in proportion to the viscid consistency of the syrup, and to the rapidity of its cooling. All the feculent and earthy matters which are in the syrup form an homogeneous whole with it, as it thus suddenly passes into a solid state. The little crystals joined together, take up a greater relative space than if they were united in larger crystals; they therefore retain within their interstices a greater quantity of molasses, and this quantity is likewise greater in consequence of the viscidity of the molasses, caused by the too abundant evaporation of the water of solution.

Under these circumstances, the molasses forms with the sugar and with the earthy and feculent matters, a sort of paste, from which it cannot ever be wholly freed; for being very susceptible of fermentation, the molasses not only becomes decomposed itself, but disposes the sugar to decomposition also, and that the more readily in proportion to the smallness of its grain.

This decomposition once being established, it continues, and the molasses is renewed without ceasing. It

therefore should not be matter of surprise, that sugar, after a waste of twenty-five or thirty per cent., still continues subject to loss in the warehouses and in its transport from one place to another.

The principles on which this method is founded prescribe a progress diametrically opposite.

The proposed result is not only to obtain from the syrup all the essential salt it contains, but also to procure it in fine crystalline forms, perfectly drained from all molasses.

It is most rational to apply to the syrup that degree of concentration which is most favourable to crystallization, and to suffer it to crystallize in vessels which, by their form and capacity, are the best adapted to the weakest degrees of concentration, and which unite all the circumstances that a fine crystallization and a prompt and easy draining require. The size and shape of the cases employed in this method are favourable to these objects, while their disposition on the channels is managed with the greatest care; and the work is reduced in all its details to the greatest economy of manual labour, time, and means. However bad the juice may be, it can be concentrated without being decomposed, and however low the degree of heat which it may be able to support, we can, notwithstanding, obtain from it the greater part of its essential salt, if not at the first product, at least at the second or third. The most favourable degree of heat for obtaining the raw sugar in the most desirable state from syrup of good and middling quality, is 88° Reaumur, (230° Fahrenheit.) The syrup, concentrated at this degree, gives half of its quantity of essential salt under the form of fine isolated crystals, from which the

syrup can be separated completely. It can be put and pulverized in hogsheads, like clayed sugar; it can, like it, be transported without waste, and remain in the warehouses without altering.

It presents no obstacles to the refiner, who can produce from it sugar superior in quality and quantity to any which can be obtained from the muscovado made by the usual method. The syrup which flows from the sugar concentrated at 88° Reaumur, (230° Fahrenheit,) being concentrated at the same degree, gives also half the quantity of the essential salt it contains. This sugar is in every respect equal in quality to the first product. Six products may be obtained in syrup of good quality, always concentrating the syrup to a degree most suitable to each produce.

The sum of the first and second products obtained by this method is equal in quantity to that obtained by the usual method in the first and only boiling, which is generally carried beyond 95° Reaumur, (246° Fahrenheit.) If the Table, which has been given in page 149, be consulted, it will be seen that at this degree three quarters of the essential salt contained in the syrup is obtained. A reference to the Table likewise shows that half of the essential salt is obtained at 88° Reaumur, (230° Fahrenheit;) the two first products of this method are, therefore, equal to the whole sum of sugar obtained by the usual method. There is thus a real benefit in the higher price of the sugar, occasioned by its superior manufacture. The sugar obtained from the third, fourth, fifth, and even sixth products, likewise give the advantage of their superior value to that of the molasses in which this sugar, according to the usual method, is left.

In this plan nothing is absolutely lost, since the reservoirs which receive the drainings are lined with lead, and the sugar is not put into hogsheads till perfectly dry and freed from the molasses, which is otherwise lost, escaping through the bottom of the cisterns, and leaking through the hogsheads during the voyage, the latter loss being frequently as much as from ten to twenty per cent. The loss of the former cannot be valued, but it must be considerable in reservoirs lined with cement or boards.

This method was reduced to practice on Monsieur Deladebate's plantation, situated at "Camp de Louise," in St. Domingo. It was there pursued with the greatest care, and the result fully proved its advantages, and sanctioned its adoption. Dutrone gives an elaborate Table* of the comparative merits of the two methods, and makes it appear that the profit arising from his arrangement is equal to eighty per cent. This is probably rated somewhat too high. We should rather state it, from his own data, to be forty-five per cent. profit, and one-eighth less labour.

With equal labour, (ninety-five negroes,) were made 235,666 lbs. clayed sugar, and 402,500 lbs. muscovado sugar. The first was the produce of seventy carreaux of land, and made under the old system, the last was the produce of eighty carreaux, and made by Dutrone's method. The clayed sugar sold at 50 f. per 100 lbs., and produced 117,833 f. The muscovado sold at 43 f.†

* Made by Mr. Deladebate himself from the books of the plantation.

† When muscovado sugar made by the old method was selling at from 30 to 36 francs per 100 lbs.

per 100 lbs. and produced 173,075 f. If from each of these sums 50,000 f. are deducted for expenses, the difference in the nett proceeds will be found to equal 55,242 f. or full eighty per cent.

If the calculaton is made upon the produce of equal quantities of land, say eighty carreaux, the produce in clayed sugar would be 269,318 lbs. and in muscovado sugar 402,500 lbs. At the same prices, and with the same abatements for expenses as above, the difference in the nett proceeds would be 38,416 f. or forty-five per cent. profit, with seven-eighths of the labour, as before stated.

The objections to this plan are its first cost, and the apparent loss of time, labour, and fuel, occasioned by the frequent concentrations.

Should all the advantages be reaped from the improved manner of conducting the process which Dutrone so confidently affirms, the mere expense of the extra apparatus would not surely have prevented its adoption. There must of necessity be a greater expenditure of time, labour, and fuel, than in the usual method. But, in the present advanced state of chemical knowledge, these would appear to be more than compensated by the great advantages which must be derived from this regular and scientific progress. Accidents and impediments are so constantly occurring in the usual process, that in the actual working of the two methods, the one under present consideration may, perhaps, be found to arrive at its completion in as short a period of time as the other; a similar remark may be equally correct on the question of extra labour. There must, however, be the very serious objection of a decided loss of fuel, and although Dutrone

would prove that there is not, he reasons on the superiority of his furnace, &c., in supplying and transmitting heat, but with furnaces equally well constructed, and pans equally well formed, there must be a positive greater expenditure of fuel in the one case than in the other. The liquor is heated and suffered to get cold; it is concentrated, and the syrup which drains from the sugar is reboiled, therefore the fuel required to bring these back to the same degree of heat which they had acquired previously to their being cooled, is certainly over and above that which would be expended in the ordinary process. This quantity depends very much on the description of the fuel employed, and the quality of the cane juice; in proportion as the latter has a greater portion of uncrystallizable matter compared to its essential salt, more fuel will, of course, be expended, as there will be a greater quantity to be reheated. It can, therefore, only be found and ascertained by experiment whether this be a fatal objection to a process, which appears to have, otherwise, so many great advantages to recommend its adoption.

Major Moody, who had the charge of the crown plantations in Gaudaloupe, informs us that this increased expenditure of fuel was one principal objection to the adoption of Dutrone's system in that Island, where the expressed cane is chiefly used in boiling the juice.

CHAPTER XII.

ANALYSIS AND PROPERTIES OF SUGAR.

According to Theophrastus, the ancients considered sugar to be a sort of honey. It has, however, as we have already shown, been long known under the form of large, hard, and transparent crystals, which we denominate sugar-candy. In this state its crystals, which are very readily concreted, contain scarcely any water of crystallization. The experiments of Berzelius show that they are composed of

Real sugar . . .	100
Water	5.6
	105.6 parts.

The *primitive* form of these crystals is a four-sided prism, whose base is a parallelogram, the length being to the breadth as 10 to 7, and the height of the prism being a mean proportional between the sides of the parallelogram. The form, however, is found to vary very much, and Monsieur Romé de l'Isle reckons seven varieties of crystals; they are frequently four or six-sided

prisms, terminated by two-sided and sometimes by three-sided summits.*

Sugar is very soluble in water, much less so in alcohol. Wenzel tells us that four parts of boiling alcohol dissolve one part of sugar, but this proportion is much greater than is given by other chemists. Lewis required twelve, and Margraff sixteen parts of boiling rectified spirits for the solution of one part of sugar. If this solution is left at rest for two or three days, the sugar separates in beautifully formed crystals. Sugar is rendered easily fusible by admixture with a very small portion of water, and it is to this property that the confectionary art owes a great number of its preparations. When sugar is exposed unmixed with any other body to the action of heat, it fuses, expands, assumes a very dark colour, slowly gives off bubbles of air, and emits a peculiar odour known by the name of *caromel.* If brought to a red heat, it inflames with a slight explosion, the colour of the flame being white, with an edging of blue.

If sugar is subjected to distillation in a close vessel, the first product is a fluid scarcely differing from pure water; this is afterwards united with a substance, which Fourcroy and Vauquelin have proved to be a compound of acetic acid, with a little oil; some empyreumatic oil is then given off, and the residue is a spongy, light charcoal, which, except that it contains the lime used in the original manufacture of the sugar, would be of great purity. Considerable quantities of carbonic acid and carburetted hydrogen gas are given off during the ope-

* Gillot. Ann. de Chim. xviii. 317.

ration. Mr. Cruickshanks decomposed 480 grains of sugar by heating them gradually to redness. The products were,

	Grains.
Acetic acid and oil, which he calls pyro-mucous acid..	270
Charcoal...	120
Carburetted hydrogen and carbonic acid gas.....	90
	480

If pieces of sugar be rubbed against each other in the dark, phosphorescent sparks are clearly visible.

Lavoisier was the first who discovered that sugar is a vegetable oxide, composed entirely of oxygen, carbon, and hydrogen. Many eminent chemists have since subjected it to examination by analysis. It will be seen from the following Table that they differ somewhat in their results, as to the proportions in which the three bodies are found.

	Lavoisier.	Gay Lussac and Thenard.	Berzelius.	Prout.	Ure.
Oxygen...	64 ...	50.63 ...	49.856 ...	53.35 ...	50.33
Carbon ...	28 ...	42.47 ...	43.265 ...	39.99 ...	43.38
Hydrogen	8 ...	6.90 ...	6.879 ...	6.66 ...	6.29
	100	100	100	100	100

The specific gravity of very pure sugar (water being one) is, according to Fahrenheit, 1.6065.* Hassenfratz† states it to be 1.4045, and Thompson 1.5629.‡

* Phil. Trans. 1724, Vol. xxxiii. p. 114.

† Ann. de Chim. Vol. xxviii. p. 15.

‡ System of Chemistry, vol. iv. p. 18.

Mr. Daniell has observed* that raw sugar, which has been kept for some time in warehouses in this country, assumes a degree of clamminess, and approaches to the nature of gum, for which reason the refiners always prefer using new sugar. Mr. Daniell attributes this change to the action of the lime, which is always found in West India sugar. Proust has stated,† that liquid sugar, so called from its incapability of crystallizing, exists in the juice of the sugar cane, and forms a large proportion of the molasses. Dutrone has classed this under the heads of sweet and saccharine mucous juice.

The taste of sugar is saccharine and sweet, with either the saccharine or sweet taste preponderating. This distinction is established among the Chinese, under the denominations of male and female sugar, the former being most saccharine, and the latter most sweet. It is a common error to suppose that highly refined sugar is less saccharine than raw sugar; the fact being that, in the most refined sugar, the saccharine taste is more developed than the sweet taste, and thus, although more saccharine, it sweetens less; the proportion used must be increased according as the sweet taste is required to be given in a greater degree. The difference in the taste of various kinds of sugar, in being more or less sweet, and more or less saccharine, and the varieties in its crystalline form, show that its constituent parts may vary considerably in their proportions, while the body continues to retain its principal characteristics. The very marked differences observable in the quality of sugar

* Quarterly Journal, Vol. vi. p. 32.

† Ann. de Chim. lvii. p. 131.

are referable to the soil and season wherein the cane has been grown and cut, as well as to the manner in which its juice has been manufactured.

Dutrone, after having spent so much time and labour in investigating, with deep research, the nature and properties of the sugar cane, and seeking, with unremitting endeavours, the best means of extracting its products, naturally enough imagines that what has so exclusively engaged his attention must, of necessity, be of the greatest possible importance to the comfort and happiness of human kind. With all the vivacity of a Frenchman, he bursts into a rhapsody on the various excellencies of sugar. He not only panegyrises it as the triumpher over seasons and climates in enabling us to assemble at our tables the fruits of every season, and of every country; as the softener of asperities, the *delice* of confectionery, the seductive charm of liqueurs; but he would exalt it as the panacea of life, the invigorator of infancy, the restorer of sickness, the renovator of old age. He invites the brewer, the baker, the vintner, &c. to prove its beneficial influence in their several arts. He calls upon the apothecary to acknowledge its aid in compounding medicines, and recommends the surgeon to lay aside his unctuous plasters, and to apply saccharine lenitives.

It would be a work of supererogation to enumerate all the various uses of sugar; it has now become so completely one of the necessaries of domestic economy, that we pity our poor ancestors, and wonder what they did without this grand sweetener of life.*

* The Hindus have a tradition showing how the sugar cane was first introduced among them, and which proves in what estimation it

Dutrone calls sugar the most perfect alimentary substance in nature, and the testimony of many physicians establishes the fact.* Dr. Rush, of Philadelphia, says, in common with all who have analyzed it, that "sugar affords the greatest quantity of nourishment in a given quantity of matter of any subject in nature." Used alone it has fattened horses and cattle in St. Domingo for a period of several months, during the time when the exportation of sugar and the importation of grain were suspended from the want of ships.

The plentiful use of sugar in diet is one of the best preventives that ever has been discovered of the diseases

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is held by them. They relate that, in very ancient times, a vessel belonging to their country chanced, by accident, to leave one of her crew under a desperate fit of sickness on a desert Island, at a considerable distance in the Eastern seas, and that returning by the same route, curiosity prompted them to inquire after the fate of their companion, when, to their utter astonishment, the man presented himself to their view, completely recovered from his sickness, and even in a state of more than common health. With anxiety they inquired for the medicine he had so successfully applied, and were conducted by him to the sugar cane, on which he acquainted them he had *solely* subsisted from the time of their departure. Attracted by such a powerful recommendation, the precious plant was carefully transplanted to, and successfully cultivated in, their own land.

* He that undertakes, says Dr. Slare, to argue against sweets in general, takes upon him a very difficult task; for nature seems to have recommended this taste to all sorts of creatures; the birds of the air, the beasts of the field, many reptiles and flies, seem to be pleased and delighted with the specific relish of all sweets, and to distate its contrary. Now, the sugar cane, or sugar, I hold for the top and highest standard of vegetable sweets.—*Edwards's West Indies.*

which are produced by worms. Nature seems to have implanted a love for this aliment in all children, as if it were on purpose to defend them from those diseases.

Sir John Pringle tells us that the plague has never been known to visit any country where sugar composes a material part of the diet of the inhabitants.

Dr. Rush, Dr. Cullen, and many other physicians, are of opinion that the frequency of malignant fevers of all kinds has been lessened by the use of sugar. Dr. Rush observes, that, in disorders of the breast, sugar is the basis of many agreeable remedies, and it is useful in weaknesses and acrid defluxions in other parts of the body.*

The celebrated Tronchin recommended "Eau Sucré" for almost every malady. Dr. Fothergill was very anxious that the price of sugar should be sufficiently moderate to render it accessible to the mass of the people. From experiments made by some eminent French surgeons, it appears to be an antiscorbutic, and this is confirmed by well-known facts.†

* The celebrated Dr. Franklin had taken large quantities of *black-berry jam* for the pain of the stone, and found benefit from it; but discovered at length that the medicinal part of the jam resided *wholly* in the sugar. From half a pint of syrup, prepared by boiling brown sugar in water, and taken just before he went to bed, he declared that he often found the same relief that he did from a dose of opium.

It has been said that sugar injures the teeth, but this opinion does not deserve a serious reflection.—*Amer. Phil. Trans.* Vol. iii.

† A vessel came from the West Indies heavily laden with sugar. A calm that had not been foreseen, prolonged the passage till all their provisions were exhausted. The sugar was the only resource left to the crew, and nourished by it, they at length arrived safely in port.

Although sugar has for so long a time been used in our alimentary preparations, it is only since it has been analyzed by the French chemists, that it has come to be considered in itself an alimentary substance. The base of sugar is a glutinous matter, which, in its proper combination, is extremely pure and perfectly soluble, and consequently in the most favourable circumstances for easy digestion. It is therefore extremely wholesome and nutritious. Of this there is abundant proof. During crop time in the West Indies, all appear fat and flourishing; the cattle which are fed on the cane tops and the scummings, become sleek, and in better condition, although more worked at that time than at any other. The negroes drink freely of the juice, and the sickly among them revive and become fat and healthy. In China and in India the same beneficial effects are recorded. We are told by Sir George Staunton, that in the former country, many of the slaves and idle persons are frequently missing about the time that the canes become ripe, hiding themselves and living entirely in the plantations.

A writer from India observes, "The comfort and health arising to a poor family from a small patch of sugar cane, exclusive of what the jaggry may sell for, can only be known to such as may have observed them in the time of cutting the canes, and noted the difference

Some sailors had died of scurvy during the voyage, and many were threatened with death from the same cruel malady. The scurvy ceased when its victims were, from necessity, reduced to the sugar diet, and the remedy was, at the same time, an agreeable aliment.—*La Gazette de Santé*, No. xliv. 1785.

of their looks before the crop begins, and a month or six weeks after."

The Cochin Chinese consume a great quantity of sugar ; they eat it generally with their rice, which is the ordinary breakfast of people of all ages and stations.

There is little else to be obtained in all the inns of the country but rice and sugar ; it is the common nourishment of travellers. The Cochin Chinese not only preserve in sugar all their fruits, but even the greater part of their leguminous vegetables, gourds, cucumbers, radishes, artichokes, the grain of the lotus, and the thick fleshy leaves of the aloe. They fancy nothing is so nourishing as sugar. This opinion of its fattening properties has occasioned a whimsical law. The body guard of the king, selected for the purposes of pomp and show, are allowed a sum of money with which they must buy sugar and sugar canes, and they are compelled by law to eat a certain quantity daily. This is to preserve the embonpoint and good looks of those soldiers who are honoured by approaching so near the person of the king; and they certainly do honour to their master by their handsome appearance. There are about five hundred of them, all equally sleek and plump, being actually fattened by sugar. Domestic animals, horses, buffaloes, elephants, are all fattened with sugar cane in Cochin China.

Sugar has been found to be an antidote to the poison of verdigris, if taken speedily, and in abundance; and, unlike many other organic substances, its nutritious qualites are not liable to change from the operations of time or seasons.

CHAPTER XIII.

ON SUGAR MILLS.

The moving power of the sugar mill is either wind, cattle, a stream of water, or a steam-engine. All windmills should be so constructed as to be capable of being worked by cattle also, upon the failure of wind, by disconnecting the sails and attaching levers to the shaft. It is of the utmost consequence that the work of grinding the canes should proceed regularly, and that they should be ground as fast as they are brought from the fields, otherwise there is danger of their juice fermenting; but these considerations in a great measure annul the economical advantages that would otherwise result from the employment of wind as a moving power; since either supernumerary cattle must be kept for the purpose, or the mules must be taken from other necessary employments.

A good stream of water, the cheapest of all descriptions of power, is an advantage which does not very generally exist in the Islands; Jamaica is the most favoured among them in this respect. In the newly settled

Colonies of Guiana, tide mills may be advantageously employed; it is obvious, however, that these cannot be constantly made available, and in these settlements, steam-engines are more commonly and beneficially used. For constant, regular work, this machine is preferable to all others, where a sufficient supply of fuel can be commanded.

In situations where neither water, wind, nor steam can be employed, a stock of mules or oxen must be kept for the exclusive service of the mill.

It does not appear that many very important improvements have been made in the plan and construction of sugar mills, since they were first used in the West Indies. Many inventions have been made with the view of economising power. The improvements adopted with most advantage are those of Woollery and Collinge. The former obtained a patent in 1773 for certain improvements which are mentioned by Edwards. They appear to have consisted, principally, in the addition of a lantern wheel, and trundles to the middle roller, which acted as so many friction wheels, and increased extremely the capability of the mill. In 1794, Collinge introduced horizontal instead of vertical rollers; these are found to be much more advantageous in some respects.

The frame of the sugar mill was formerly made of wood, and the rollers were formed of hard wood covered with plates of iron or steel. This kind of roller is now entirely abandoned for others which are hollow cylinders of cast iron, turned with the greatest care. Until a comparatively recent period, the cylinders were invariably placed in a vertical position, and on a line with each other, which arrangement is still very generally

adhered to. These cylinders, which are always three in number, are from thirty to forty inches in length, and from twenty to twenty-five inches diameter. They are furnished with cog-wheels, fixed on the upper ends of their peripheries, and working into each other; the moving power being then applied to the middle cylinder, the whole are by this means set in action.

The rollers are mounted in an iron frame, consisting of two horizontal pieces, sustained by uprights; the openings of the frame contain brass bearings for the pivots of the three rollers, which brasses are capable of adjustment by means of cross keys, and wedges driven through openings in the frames, so as to force the rollers towards each other, and retain them at regular and unvarying distances. The surfaces of the rollers are fluted with grooves of a small depth; these occasion the rollers to take a firmer hold of the canes to draw them forward, and also facilitate the running down of the juice from the canes into a pan or cup, which is formed round the rollers at the lower part by a plate of iron turned up all round at the sides, and placed on the bottom of the frame; at one side of this there is a spout to convey the juice into a pipe which leads to the boiling house. This receptacle for the juice forms a small circular channel round the lower edge of each roller, and a small raised rim is carried round the centre part, or pivot of each roller, the edge of which being higher than the surface of the liquor in the pan, prevents the juice from flowing down into the bearings of the lower pivots. The weight of each roller, which is considerable, is supported in a brass step, or bearing beneath the frame, and in some cases friction rollers are applied beneath.

The operation of this mill is extremely simple. The canes are pressed twice between the rollers, being made to pass first between the middle roller and that on the one side, and then between the middle roller and that on the other side. This was formerly performed by hand, a negro standing at each side, one feeding the mill by placing the ends of the cane between two of the cylinders, and the other bending the canes as they came through and holding them in contact with the surface of the centre roller, so that it might carry them round by its motion and introduce them again between itself and the other roller, where they came out again quite deprived of their juices. They now, however, employ what is called a dumb returner, which has had the effect of lessening the number of accidents in feeding the mill. This is a circular piece of frame work, or kind of screen, which is fixed fast to the upper and lower frames, and is made to encompass the middle roller at the back. It receives the canes as they come through the first time and holds them in contact with the middle roller, till the ends return between the other pair of rollers. This is the invention of Mr. Bell, a sugar planter who resided in Barbadoes. The second pair of rollers are adjusted by the wedges of their bearings, so as to be rather nearer together than the first pair, because the canes are flattened and crushed by the first pressure between the rollers, and require a still greater degree of pressure the second time they are passed. The space between the rollers is very small, in either case, not exceeding a quarter or three-eighths of an inch, and the canes are, consequently, squeezed excessively hard in passing between them.

When the mill is turned by cattle, the axis of the middle roller has long levers fixed across it, the arms to which the cattle are attached must extend at least eighteen feet from the centre, and, to render the arms firm, the axis of the roller is carried up to a considerable height, and oblique braces of wood are extended from the extremities of each of the arms by which the oxen or mules draw, to the top of the vertical axis, thus forming a triangle. Two mules are fastened to each arm; for a small mill two arms are sufficient, but in larger ones four arms must be provided, to admit of six or eight mules to turn it.

When a water wheel is applied to turn the mill, a large bevelled wheel is fixed on the top of the axis of the middle cylinder, and the motion is communicated by a bevelled cog-wheel fixed on the end of the axis of the water wheel.

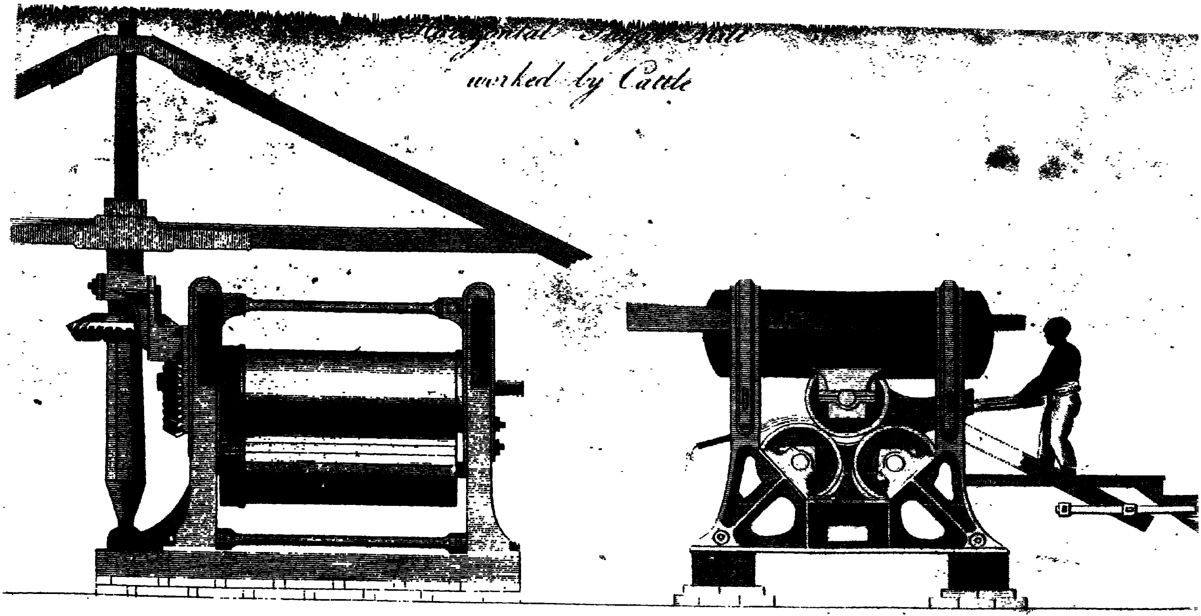
When a steam-engine is the moving power, the bevelled wheel on the axis need not be nearly as large as when it is turned by a water wheel; in this case a bevelled cog-wheel gives the motion by being fixed on a horizontal shaft, on the other side of which there is fastened a large cog-wheel, and this is turned by a pinion fixed upon the end of the axis of the crank, or working shaft of the steam-engine.

There is perhaps no real advantage in placing the rollers vertically; when the mill is empty, vertical rollers may indeed run more easily than such as are horizontal, but this apparent advantage ceases when any substance is interposed between them, giving them a tendency to deviate from the perpendicular; and as horizontal mills can be fed more regularly over their whole

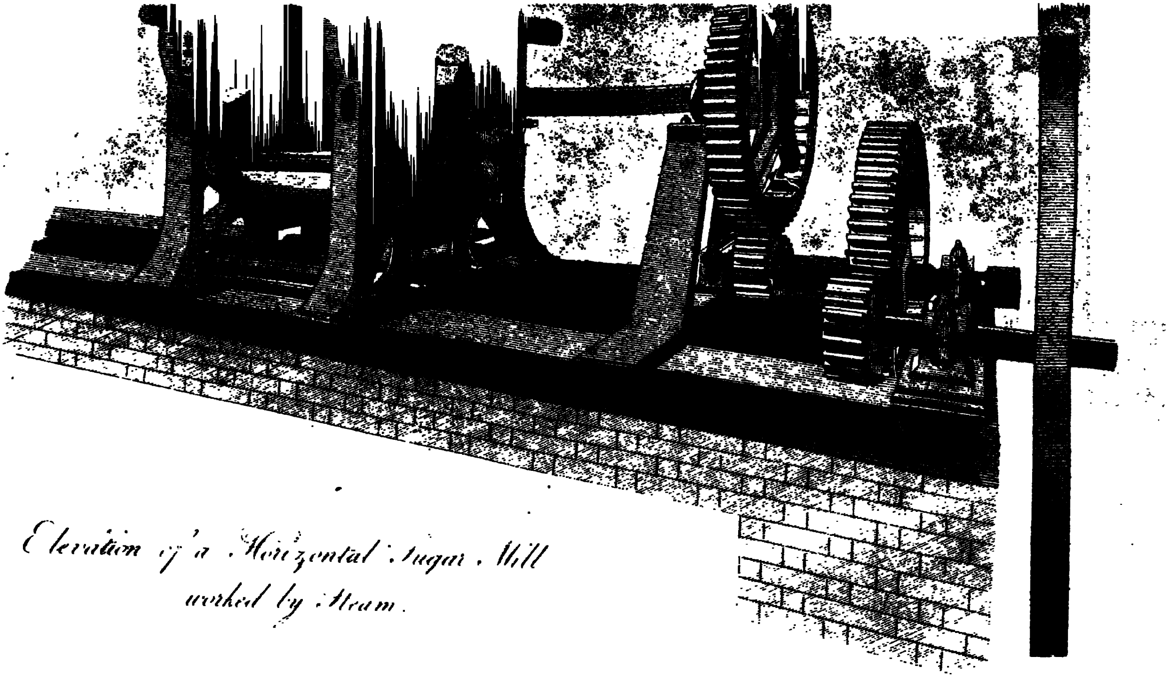
length than those which are vertical, this cause of derangement is more likely to occur with the latter than with the horizontal rollers. The vertical position was originally given as being most convenient for applying the power of cattle, and for allowing all the juice to run freely into the mill bed, without any re-absorption by the expressed cane.

In horizontal mills the rollers are arranged in a triangular form, one above and two below; the power is applied to the upper roller, and motion is communicated from it to the others by an arrangement similar to that used with vertical mills, as already described. The two lower rollers are placed very near to each other, so that the canes are made to pass from the one to the other, but these two rollers, moving in opposite directions, cannot of course, be suffered to come in contact. From this description it will be seen that the upper one answers to the middle, and the lower ones to the two outside rollers of the vertical mill. The two lower rollers are contained in a small cistern, which serves to receive the cane juice when expressed.

The advantages of placing the rollers horizontally appear to be considerable. It has already been said that the feeding of the mill can be more regularly performed, and this is done by spreading the canes evenly and regularly on a board or bench which is placed in a sloping direction leading to the space between the upper part of the first lower roller, and the lower part of the upper roller. The canes being pushed forward upon this bo[illegible]r between the two rollers and are carried forwa[illegible]he other roller, and thus subjected to a second pressure, without the aid of the returner. In vertical



Horizontal Sugar Mill
worked by Cattle



Elevation of a Horizontal Sugar Mill worked by Steam.

mills it is not at all unusual to find the rollers wear out in one part, generally about ten or twelve [illegible] from the bottom, while the rest of the [illegible] fect. The more regular feeding of [illegible] its more equable working, and lessens [illegible] dents from jirking and straining. For [illegible] the rind of the cane is less bruised, and its [illegible] broken in the passage between the cylinders, [illegible] the canes are carelessly crowded through the cylinders, intersecting and overlapping each other. [illegible] quence, the cane juice expressed by a horizontal mill is said to be much clearer and many shades lighter than that yielded by the vertical rollers.

A full-sized horizontal mill should have rollers [illegible] feet long, with a diameter [illegible] is smaller, a greater speed [illegible] order to produce an equal [illegible] will [illegible] be more bruised [illegible] cylinders are em ployed. A mill of these dimensions, propelled by a ten horse power steam-engine, is capable of grinding with ease, in twelve hours, canes sufficient to make three hogsheads of sugar. With [illegible] such a mill has been made to yield 840 gallons of juice in an hour and a quarter.*

When the canes have, as before described, passed twice between the rollers, they are received on another inclined board, which has sufficient slope to carry the cane trash from the rollers and deliver it in a heap on the ground, whence it is taken, from time to time, and conveyed to the trash house.

As the whole success of the crop is endangered by any accident happening to the mill, it is of the first impor-

tance to have this faithfully and strongly constructed and put together; nor will it be found prudent to look too closely to the cost of a machine, the maker of which can find many ways for securing his usual rate of profit, even where the price has been fixed at an apparently moderate rate. Where so much real difference exists in the intrinsic value of the materials used, as well as in the quality of the work supplied, it must surely be the truest economy to pay a fair price to some tradesman having a reputation to sustain, rather than to seek after a lower priced commodity, which may show its deficiencies at a moment when the consequences would prove truly disastrous.

Where steam-engines are employed in the Colonies, we believe they are always on the low pressure or condensing principle, which is, perhaps, one reason why their use has not been more extended. Reducing, as steam power does, every operation to a certainty, it must be advantageous to call in its aid wherever it is practicable; but engines of this construction, besides being expensive in fuel, require a very abundant supply of water for condensation, and this is not always within the command of every plantation. In the newly-settled Colonies of Guiana, where water is in great abundance, steam-engines are almost universal, even where resort can be had to the much cheaper agency of tide mills, since these latter are, of course, intermitting in point of time, and are found to be less regular in their performance. High pressure engines, which are the simplest of all steam-engi[illegible]he least expensive in their construction, [illegible]with one-seventh part of the water requ[illegible]densing engines. If properly made and

rightly proportioned, they are less wasteful of fuel, they are of smaller weight, and occupy less space; while, from their greater simplicity, they are more easily kept in repair. An opinion unfavourable to the use of hi pressure steam undoubtedly exists, through appreh sion of danger, and it is certain that this apprehension was formerly well founded; this, however, is no longer the case, and we believe it will be found, upon inquiry, that the proportion of accidents occasioned by the bursting of boilers, is greater with condensing than with high pressure engines.

CHAPTER XIV.

ON PATENTS FOR IMPROVEMENTS IN THE MANUFACTURE OF SUGAR.

The enlightened sugar planter has always felt that the plans pursued in manufacturing the juice of the cane are extremely defective; that numerous difficulties are encountered, and many accidents are constantly occurring, which cannot be avoided by any degree of foresight or skill, while the absence of these qualities cannot fail to accumulate those evils tenfold. A scientific view has too rarely been taken of the subject, and instead of improvements and reforms founded on a chemical acquaintance with the nature of cane juice and with the causes which produce the evils sought to be remedied, only palliatives and expedients have been offered. Dutrone has conducted his investigation in a most philosophical manner, and appears to have indicated all the points which require peculiar attention.

After the juice is safely arrived free of all taint from the mill, the difficulties of converting it into sugar arise from the following causes. First, from the improper use of temper. Dutrone shows us how to regulate this with somewhat of methodical exactness, and how by its

means, seconded by filtration and subsidence, to get rid of the feculencies: this is another most difficult, and, in general, most imperfectly performed task, and proves another important cause of the bad quality of sugar. The immoderate application of heat, by charring and partially decomposing the sugar, is the third cause of injury; this Dutrone professes to have entirely obviated by his method; but although, by extreme vigilance, the frequency of its recurrence may be avoided, a careless operator or neglectful negro may still work the mischief. The fourth cause arises from the imperfect mode of curing, and in this respect his plan seems to be very much preferable.

The reform and new arrangements in the sugar house which he proposed, do not appear to have been much known beyond the Island of St. Domingo, where he resided; these shared the fate of the white inhabitants and proprietors of that beautiful Island, and after the expulsion thence of the French, his method appears to have been devoted to oblivion; this circumstance, however, affords no proof of the inefficacy or inappropriateness of his plan. The political events which convulsed France at that period, and which for so long a time afterwards engrossed the whole of Europe, were causes sufficient for such a work being disregarded, at least for a time. The French, with the loss of their most important Colony, lost the incentive and the necessary means for introducing improvements into their other possessions, and of late years the whole of their attention on this subject has been directed to the manufacture of sugar in their own country from a plant of domestic production.

The actual improvements hitherto effected in our own Colonies appear only to consist in the use of separate clarifiers, and in the gradual decrease of the relative depth of all the pans; experience has taught us that the quicker the evaporation is carried on without danger of charring, the better is the quality of the sugar; and shallow vessels are, of course, more advantageous for this purpose, as they expose a greater relative surface.

The clarifiers at present in use were first introduced in 1778, by Sainthill, a resident West Indian planter. It appears that he obtained at that time, an exclusive patent for his invention in Jamaica, but his name is not in the list of English patentees.

There are three clarifiers, each hung to a separate fire and chimney, with a damper for extinguishing the fire. These vessels are nearly flat at the bottom: if they were quite flat, they would have a tendency to warp, and therefore the bottoms are slightly arched, to give strength, thus forming a concave outer surface; each clarifier is provided with a syphon, or cock, to draw off the liquor.

The dimensions are generally in these proportions: for

		ft.	inches.			
400 galls.	capacity,	6	10	diameter,	21	inches deep.
350	”	6	6	”	20	”
300	”	6	2	”	19	”

The advantages of these clarifiers have been shown in the account of the process already given.

The other pans have still the disadvantage of the elliptic form, which wastes the fuel, and renders the liability to burning very much greater than if they were flat-bottomed; and especially in the emptying, it is scarcely

possible to avoid charring; hence the frequent cleansings required, to the manifest injury of the sugar, occasioned by the delay of the work, and to the wear of the vessel, which, every time it is cooled after excessive heating, scales off, and becomes, consequently, thinner. The evaporating vessels are segments of spheres, with rather a broad lip. Their dimensions are in this proportion:— For

one set.	230	galls.	66	inch.	diameter and	24	inches deep.
	160	”	62	”	”	20	”
	110	”	54	”	”	18	”
	70	”	48	”	”	15	”
	45	”	42	”	”	13	”
one set.	130	”	57	”	”	20	”
	80	”	48	”	”	17	”
	50	”	42	”	”	14	”
	34	”	36	”	”	13	”

The system carried on in the manner we have described in Chap. VII. seems to have been continued, with only the improvement of giving a diminished depth to *the boilers, from 1778 to the present time: many inventions have been made for the better manufacturing of* the cane juice, but *have hitherto been only very* partially, if at all adopted. In 1784, Bousie not only obtained a patent for making sugar from cane juice, but likewise received from the Assembly of Jamaica £ 1000 for his improvements: we are not aware in what these improvements consisted, except that he appears to have investigated the nature of the alkalies, the peculiar effects of various alkaline substances, and the best mode of applying them in clarifying the juice.

In 1786, Murray took out a patent for clarifiers: from the description given of these, we cannot discover in what respect they differ from Sainthill's, so as to warrant the grant of an exclusive patent.

From that time to the year 1816 there seem to be only four claimants for the exclusive right of using their several inventions, of which we know nothing except that they do not appear to have been adopted.

In 1816, Mr. Philip Taylor obtained a patent for heating fluids, by passing high pressure steam through tubes immersed in the fluids. We cannot learn, however, that this has been introduced into the West Indies.

In 1816, Mr. John Hague patented certain improvements in the method of expelling the molasses and syrup from sugar; but as he has only lately secured his patent for the Colonies, and as it is only very recently that it has been at all known there, we will defer an account of his method till we come to the description of inventions proposed about the date of his Colonial patent.

For the last few years, attention seems to have been alive to this subject, and the list of patents is crowded with competitors for remedying every defect that has been found in the manufacture of sugar. In the present time, certainly, some very valuable discoveries have been made, and those among them which, on trial, are found to possess advantages, will, no doubt, in time be adopted, and very much facilitate and improve the process.

We propose giving an account of such as appear to be in any way worthy of attention.

In 1818, Mr. Daniel Wilson obtained a patent for

certain improvements in clarifying sugar. He proposes putting to every hundred gallons of juice eight ounces of sulphate of zinc, the sooner after the juice has been expressed the better; the temper of lime may be added a few minutes after, and the quantity of this temper should be increased at the rate of two ounces to the hundred gallons of juice, to neutralize the acid contained in the sulphate of zinc. He observes that there are two kinds of impurities in the juice—the one chemical, the other mechanical; the latter can be removed by mechanical means, but the former being actually dissolved, and in intimate union, can only be extracted by a chemical action: this he proposes to accomplish by sulphate of zinc, which combining with the chemical impurities, forms with them an insoluble compound, that reduces them to the state of mechanical impurities, which may be separated by filtration.

He considers the most abundant of these chemical impurities approach to what is called by the chemists *extractive* matter, the others are tannin and gallic acid, which he asserts to have existence in the cane juice; all these form insoluble compounds with, and are precipitated by, sulphate of zinc, or tin.

Mr. Wilson's plan has been repeatedly and carefully tried in the West Indies; and, had the effect which he anticipated resulted from it, his discovery would have been of the highest value to the planter; but one intelligent gentleman, who put the matter to the test, assures us that no beneficial result whatever followed the employment of sulphate of zinc, as proposed by Mr. Wilson.

In August, 1823, Mr. James Smith patented an

invention for evaporating and concentrating solutions in general, boiling sugar, &c. This principle consists in giving any graduated degree of heat required, by means of compressed steam, which has the advantage of not burning any material submitted to its action.

It is proposed to apply this principle to the boiling of cane liquor by means of double bottomed vessels, the space between the two vessels forming the steam boiler. To this the fire is applied, and steam is raised of the required density, regulated in the usual manner by loading safety valves. It is not proposed to subject the clarifiers to the action of steam, but to apply to them a more gentle degree of heat, by means of the warm air of the flue, previous to its passing into the chimney.

The bottoms of the boilers are flat, and the spaces between them and the bottoms of the sugar pans form the boilers, which need not exceed a foot in depth for the largest apparatus. Cocks are fixed to each of the boilers, to draw off the water. The patentee recommends that the pans should project beyond the boilers, that the sides being thus cooler than the other parts, the fluid may be prevented from boiling over, and the scum, as it forms, thrown on the sides and collected with greater facility. The steam being applied to every part of the bottom of the pan, communicates its heat to the liquor therein, and, being thereby condensed, descends in the form of water to the bottom of the boiler, and is again raised into steam by the heat of the fire underneath, so that the operation continually goes on, of generating and condensing in the same vessel, thus dispensing with force pumps and complicated feed pipes. However unequally the fire may act on the boiler, the effect on the bottom

of the sugar pan is perfectly equalized by the intervening stratum of steam. The steam boiler and sugar pan are made of thin copper or iron; and to give sufficient strength to large surfaces, it is proposed to tie them together by rivetted bolts at short and equal distances, thus enabling thin metal to resist the required degree of pressure.

We are not aware that this invention has been at all introduced into the West Indies. To render the medium of steam effective in boiling sugar, it must be used at a high degree of pressure, and this, joined to the probability of the apparatus being constantly out of repair, are, perhaps, sufficient reasons for its not being adopted.

In 1824, Mr. Cleland took out a patent for improvements in the process of manufacturing sugar from cane juice, and in the refining of sugar and other substances. This invention is to operate on the sugar after it has been sufficiently concentrated in the teache, and previously to its being put into the hogsheads. He proposes to run the syrup through long narrow linen bags, which, he says, causes it to part with its molasses more freely, and to crystallize more perfectly. This apparatus consists of broad wooden troughs, or reservoirs, only four or five inches deep. The bottoms of these troughs are perforated with a considerable number of circular holes, of a conical figure; that is to say, the upper parts of the holes are about two inches diameter, and the lower an inch and a half; the holes are thus made, to fit and receive the necks of the long suspended bags, which admits of their being easily removed when required. The bags are made of linen duck: they are of a cylindrical form,

three inches diameter and six feet long, with necks of the dimensions before mentioned, made of woollen cloth, the circular figure of which is preserved by a metallic collar, or casing; altogether, much resembling in figure apothecaries' phials, except that the bags are of greater proportional length. The bags are made with their lower ends open; and these, in the first part of the operation, are securely tied with string; they are then placed in the several holes, suspended by their necks, when the syrup from the teache is admitted into the trough, gradually filling all the bags; the crystallizable portion speedily forms itself into sugar, while the molasses, percolating through the mass, passes through the interstices of the linen bags in all directions, and drops into receivers placed beneath them for that purpose. When the draining is considered complete, the receivers are removed and the lower ends of the bags untied, when they deliver the sugar into other recipients. If necessary, the bags may be lifted out of the troughs by their necks, and their contents removed by turning them inside out.

We have not heard that this method has been introduced into the West Indies; indeed, it appears to us that this elaborate apparatus is liable to many objections without offering any adequate advantage. If it were applied at an earlier stage of the process, before the concentration of the syrup, it would, no doubt, prove efficacious in separating the feculencies which might have escaped the scummer, but it is very doubtful whether such a system of filtration would be found more efficient than a simpler method, or than the plan for filtration and subsidence proposed by Dutrone, as already described.

Mr. Constantine Jennings obtained a patent, in 1825, for improvements in clarifying raw sugar. His method is founded upon the fact, that alcohol possesses a much stronger affinity for colouring matter than for the saccharine principle. As the efficacious application of this property in alcohol cannot be doubted, the question resolves itself simply into one of economy. The process is thus described in the specification of the patent.

Raw sugar, of from five hundred to one thousand pounds weight at a time, is to be put into a conical vessel, having an aperture at bottom, covered with wire gauze; rectified spirit, obtained either from rum, wine, brandy, or any other liquor, is then to be poured into the vessel, which, as it percolates through the sugar, carries off the colouring matter, and other impurities, through the aperture at bottom. When the spirit has ceased to drip, about thirty gallons of saturated syrup may be poured upon the mass of the sugar, which, penetrating through every part, takes up the remaining spirit, and leaves the sugar in that moistened state, in which it is put into hogsheads, to be ready for the market. The process of percolation may be expedited by hydrostatic, hydraulic, or any other of the usual means resorted to for forcing liquids through compact substances, whose particles are not in a state of actual cohesion. The patentee states that he has found alcohol operate more rapidly and effectually in refining sugar than any other liquid heretofore employed. We believe the expense of this process has prevented its adoption. To make the cost of it as small as possible, however, Mr. Jennings recommends that the spirit, which has combined with the colouring matter, the water, &c. should be used over again in clarifying inferior sugar;

and when it has become too thick, or too much charged with colour for the operation, the pure spirit is easily recovered by rectification.

Mr. William Fawcett, of Liverpool, in December, 1827, patented an improved apparatus for the manufacture of sugar from the juice of the canes. This consists in the employment of high pressure steam, which is applied to a series of sugar pans for evaporating and concentrating the saccharine fluid to the consistency at which it crystallizes. The boiler is made capacious enough to supply steam for this purpose, and for working a steam-engine. There are five sugar pans arranged side by side, and set over a boiler; each of these five pans is surrounded by a jacket, or case, for the steam to envelope them. The furnace is formed of large tubes *within* the boiler, after the manner of Trevithick's, and the flue from thence passes under two other pans without cases, before it enters the chimney. The two last-mentioned pans are therefore operated upon by heated air, instead of steam, in order that the remaining caloric may be abstracted from the smoke, &c. before passing up the chimney. There are thus seven pans in all, five being worked by steam and two by heated air. The boiler is provided with safety-valves, stop-cocks, floats, steam pipes, and other necessary appendages to the foregoing; one pipe leads to the engine which works the crushing-mill, and another returns the condensed hot water to the boiler.

This arrangement is said to have been successfully tried in Jamaica. It appears to us that the same objection would apply here, which has been urged against the employment of high pressure steam under Smith's

patent, namely, its danger, from the degree of elasticity at which the steam must be used, and the great liability to derangement of the apparatus, in a country where engineers are not very numerous, and where few, if any, among them can lay claim to the skilfulness and ingenuity of the inventor. The unavoidably high cost of such an apparatus must also be a considerable drawback to its adoption. The circumstance of the surplus steam being employed in actuating the steam-engine, can scarcely be said to increase the advantage of the apparatus, as the boiler must, for this purpose, evidently be made large enough to furnish steam in sufficient volume for both operations, and can thus be very little more economical than the employment of two smaller boilers.

Mr. Stokes, in 1828, took out a patent for improvements in preparing raw sugar and molasses; if these be improvements they certainly are not discoveries, or inventions, of the patentee. They are thus described:—The cane juice is to be mixed with fourteen pounds of charcoal, seven pounds bark of the wild elm tree, and one pound of lime. After standing some time, the juice is to be filtered through blankets, and then removed to the boiling-pan, where it is to be concentrated until it will take the granulated form. After this, it is to be poured into boxes, or potted in earthen moulds. Before packing the sugar in hogsheads, it is to be mixed with common spirit, either brandy, rum, or geneva, in the proportion of one gallon per cwt. In this moistened state it is submitted, in proper boxes, to the action of an hydrostatic, or other press, by which means the moisture is expelled and the quality and the colour of the sugar are much improved. This patentee has made a curious omission in the specification;

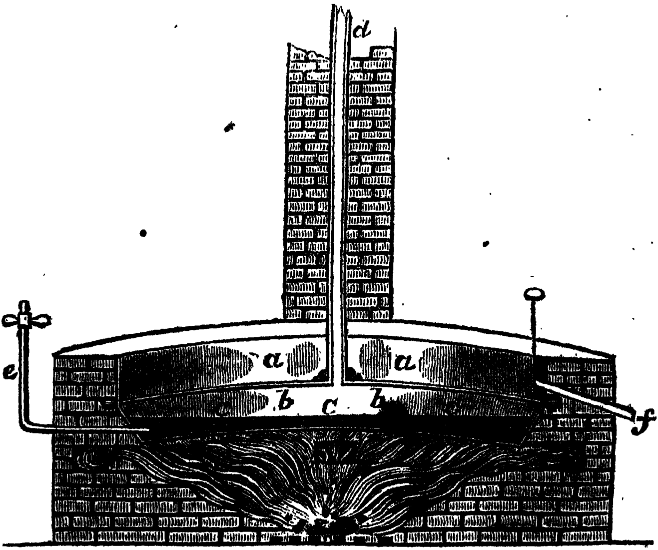
he has neglected to state the *quantity* of cane juice to which the given quantity of charcoal, &c. should be applied.

In the year 1828, Mr. J. T. Beale and Mr. G. R. Porter obtained a patent for the invention of a new mode of communicating heat, which is applicable to a great variety of purposes, but to none can it be rendered more advantageous than to the manufacture of sugar from cane juice. This invention affords the means of regulating and controlling degrees of heat with the most absolute precision. This desirable object is attained by transmitting the caloric to the syrup through the intervention of certain fluid substances, which, unless they are purposely subjected to pressure in close vessels, can never be made to indicate beyond certain degrees of temperature: so that the degree of heat best adapted to any particular operation being known, a fluid medium may be chosen and applied which will communicate that degree and no more. It will be seen that this plan embraces every advantage that can result from the use of high pressure steam, and that, at the same time, all the danger, complication, and liability to derangement attendant upon steam heating are avoided. The absence of all elastic pressure tending to rupture the vessels is proved by keeping up a constant communication, (as will be hereafter explained,) between the fluid medium and the atmosphere. The maximum degree of heat being, by this arrangement, altogether independent of accident or want of skill in the attendant, no injury from burning can possibly take place, unless through the choice of an improper fluid medium, which need never occur, as substances may be chosen capable of

communicating any given temperature between the boiling point of water, or even lower, and the melting point of lead.

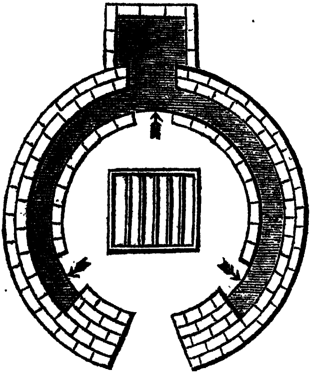
It has been shown in the preceding pages, that cane-liquor is not capable of bearing, without injury, exposure to high degrees of heat, and that liquor of middling or bad quality in particular, is incapable of being brought, without decomposition, to indicate 250° Fahrenheit. Nothing exemplifies this more clearly than the constantly recurring necessity for cleansing the coppers, particularly the striking teache, and removing the particles of burnt sugar which adhere abundantly to their surfaces.

The arrangement for employing this method of heating can be best explained by a reference to the annexed diagram.



It will be seen that this is a compound vessel, the upper part *(a, a)* forming the evaporator or teache, and the lower part *(b, b)* containing the fluid medium *(c, c, c,)* indicated by the shading. The exact depth of this fluid is no farther material than as it is necessary perfectly to cover, and thus to protect from the injurious action of the fire the bottom of the vessel. This bottom is, for the purpose of imparting strength, made slightly concave, and a similar form is given to the bottom of the upper vessel, in order that the syrup or sugar may flow off more readily through the sluice cock *(f;)* the small tube *(e)* is inserted near the bottom of the lower vessel, for the purpose of supplying the fluid medium, and may be furnished with a cock at its lower part where it enters the brick-work to draw off the liquid again if necessary. The tube *(d,)* which rises from the centre, is open at both ends; the lower extremity is carried through the upper surface of the lower vessel; it is then made to pass through a condensing vessel charged with water, and its upper end opens to the air. The use of this tube, or breathing pipe, is to allow, in the first place, the escape of the atmospheric air contained in the vessel *(b, b,)* which air being specifically lighter than the vapours furnished by the fluid media, will, of course, be driven off so soon as these are made to boil. This breathing pipe serves likewise to demonstrate the entire absence of all elastic force in the vapours of the fluids employed for heating, and stands in the place of a safety valve. The fluid medium, from its small capacity for heat, is very speedily made to boil, when the vapour which it gives off is

brought into contact with the bottom of the copper or teache, which being colder than the vapour, this is immediately condensed, and returns in the fluid form to the bottom of the vessel *(b, b,)* to be again continually vapourized and condensed as before. In resuming the liquid state, it is necessarily made to part with that portion of its heat to which its vapourous form was owing, and this occasions the heating of the contents of the vessel *(a, a.)* The tube *(d,)* in addition to the uses already mentioned, would serve, in conjunction with the condensing vessel with which it is connected, to condense and return any of the vapourized medium which may have escaped condensation by the contents of the copper *(a, a;)* so that, except from very gross negligence, little or no loss of the fluid will be sustained. The first cost of the fluid agent is very moderate, and to supply the waste of a whole season could not entail an expense beyond a very few pounds. This invention has been put to use in the West Indies, and has been pronounced by a very intelligent practical planter, to answer every end proposed by it, and to be "a very great improvement generally." Hitherto its use has been limited to the striking teache, which has been hung to a separate fire. The annexed plan will show the arrangement of the furnace and flues, which are thus disposed, in order to insure the equal distribution of the flame over the entire surface, the apertures being so calculated that the rarefied air cannot all pass through the entrance to the chimney, and a part must be drawn through the side flues in the direction indicated by the arrows.



The success which has so eminently attended the employment in this country of this mode of heating, makes it very desirable to give it a trial upon an extended scale in the Colonies, so as at once to realize all the advantages offered by the employment of regulated and safe degrees of heat throughout the entire process of sugar making. Another most important benefit which has been found invariably to accompany its use, is an extraordinary saving of fuel, declared to amount, in all cases, to more than one-half, in some cases to two-thirds, and, in one instance where it has been applied on an extensive scale, to three-fourths of the fuel previously used in the same processes. If this economy is considered of moment in England, where fuel is to be procured in inexhaustible quantities, surely it must be doubly important in the Colonies, where the furnace is made to rob the soil of its natural manure, which must be made up by the expensive expedient of maintaining herds of cattle, or by costly importations from Europe.

Although the greatest danger of burning undoubtedly exists in the striking teache, which is immediately ex-

posed to the fiercest action of the fire, yet we have seen that the nature of cane liquor renders it liable to injury and decomposition at every stage, and with a degree of heat far less intense than that applied to the striking teache. The expense attendant upon the adoption of this mode of heating throughout the entire set of evaporating and concentrating vessels should not prove a sufficient obstacle where the advantages are so great and so apparent; against this expense may be placed the value of the old vessels, which would return a large proportion of the outlay, and also the greater duration of the double vessels. The coppers themselves, it is evident, could not burn, and it is equally clear that no great degree of injury could happen to the bottom of the vessel containing the fluid medium, as it would always be protected from over-heating by a limpid fluid, having the property of rapidly conducting heat. The circular form given to the teache in the foregoing diagram is not, perhaps, the best that could be adopted, and especially if more than one vessel were used. It would probably be better to use rectangular vessels, against the entire (flat) bottoms of which the fire should be brought to apply. In this arrangement the fire might be made, as now, under the teache, in a furnace of equal width with the teache, and the heated air might be conducted under the whole of the vessels without any side flues, until it enters the chimney. The entrance to the chimney should, in this case, be an aperture, having the same width as the furnace, with an area proportionate to the area of the furnace, and its draught should be regulated by means of an ordinary damper. This method, simple as it is, has been found to insure the greatest

and most equable effect, combined with the greatest economy of fuel. Where draughts are artificially created by means of complicated flues, it is seldom that the fire can be faithfully applied to the whole surface, and while one portion is left comparatively cold, another may be most intensely and injuriously acted upon. Rapid draughts, which are always necessary where the furnace is contracted, likewise occasion great waste of fuel, a considerable portion of heat passing off unproductively.

Dr. Higgins, who seems to have been fully convinced of all the evils attendant upon the mode of heating usually employed, has observed* that "the frying and empyreuma takes place, not at the bottom of the vessel nearest to the fire, and the last to be emptied, but at the sides first emptied, but still coated with fused sugar, more distant from the fire, but nearest to the glowing circular wall." It is singular that, with this fact before his eyes, and with a knowledge of the necessity for getting sugar quickly off the fire to prevent, as much as possible, this charring and empyreuma, Dr. Higgins did not see the simple and natural remedy of applying heat only to the bottom surface of shallow vessels, from which a rapid evaporation could be insured. The remedy which the Doctor proposes is, "to set the first teache at a distance twice greater than customary from the sides of the furnace, and about three times greater from the circular face of the end wall!" The tendency of heat is to ascend, and it is well known that side heat has compa-

* Observations and Advices for the Improvement of the Manufacture of Sugar and Rum. By Bryan Higgins, M. D. Printed in Jamaica, 1797.

ratively but a small effect, so that, although coppers of an elliptic form have a greater actual surface, their effective surface is by no means proportionate, even when the vessels are full, and it is manifest that the upper portion becomes worse than useless when left bare by the diminished quantity of the syrup. The surface of a flat vessel, on the contrary, is always effective, and never can become injurious while covered by a fluid capable of absorbing and carrying off the heat. There would be no difficulty in setting vessels of this form, with such a variation in their levels that the contents of the clarifier could be drawn off through a sluice to the first evaporator, thence in the same manner to the second, and so on to the striking teache, which would be found greatly to abridge the labour of the attendants. As the heat required in the clarifier is much below that used in evaporating and concentrating the cane liquor, a fluid may be employed as a medium for communicating the exact degree proper for that part of the manufacture. It may, perhaps, be thought, that as the contents of the clarifier are never allowed to boil, no injury from overheating need be apprehended or guarded against in this vessel; a little reflection, however, may serve to show, that as various solid extraneous matters are then mixed with the juice and subside to the bottom, they there act so as to intercept the passage of heat, become themselves in consequence, overheated, and thus communicate injury to the whole mass, which is then in a state the most susceptible for receiving it. The researches of Dr. Prout and many other celebrated chemists, prove that sugar, even in its state of greatest purity, is peculiarly susceptible of injury from heat, whether from excess in degree

or in duration, and as we have seen that cane juice, when in combination with its feculencies, is more easily decomposed than when those feculencies are removed, it is plain that no degree of caution can in any part of the process be considered superfluous, in order to obtain its produce in the greatest purity.*

Mr. Godfrey William Kneller has lately patented an invention for improvements in evaporating fluids, and his plan is successfully used in an extensive sugar refinery in London. It will be seen from the following description, that Mr. Kneller's process can be readily applied in the Colonies. The apparatus consists of a set of pipes which are inserted in the liquor to be concentrated, and which reach nearly to the bottom of the pan. Through these pipes air is forced by means of bellows or any other blowing contrivance, and this air, escaping through the fluid, serves at once to reduce its temperature and to carry off the watery vapour with much greater rapidity than where the strongest heat is applied, under the most favourable circumstances, but

* The quality of sugar varies occasionally to so great a degree as to create a difference in its marketable value of upwards of ten shillings sterling per cwt., the whole of which is clear profit, the duties and charges being precisely the same on muscovado sugar of whatever quality. Thus fine sugar has been known to yield a clear profit to the planter of no less than fifteen hundred pounds sterling on two hundred hogsheads of the usual magnitude, beyond what the same number, where the commodity is inferior in quality, would have obtained at the same market. To aver that this difference it imputable wholly to soil and seasons in the West Indies, or to the state of the British markets, is to contradict common observation and experience. Much, undoubtedly, depends on skill in the manufacture.—*Edwards's West Indies.*

without this operation. Mr. Kneller's process seems to offer the means for concentrating syrup at a temperature equally low with the celebrated vacuum apparatus invented by Mr. Howard, and with a degree of simplicity which renders it attainable by the sugar planter, which cannot be said of the very scientific but complicated apparatus of Mr. Howard. It is well worthy of consideration and trial, whether Mr. Kneller's patent, used in conjunction with that of Messrs. Beale and Porter, would not effect all the improvement of which the process of sugar boiling is susceptible, by preventing all possibility of burning, and by abridging the time during which cane liquor must be subjected to the action of heat.

The invention of Mr. John Hague, to which we have already alluded, and which has passed, by purchase, into the hands of Mr. John Innes, was patented under the title of "certain improvements in the method of expelling the molasses or syrup from sugar;" for which purpose it is found to be altogether effectual. It can be easily adopted on any estate having a steam-engine, or any other means of working powerful air-pumps. This process is carried on by placing the sugar in a vessel or trough, having a perforated false bottom. Connected with the space between the two bottoms is the suction pipe of the air-pump, and when this is set in action, and a partial vacuum is formed, the air rushing through the sugar, as it then naturally must, carries with it, through the perforations of the false bottom, all the molasses, leaving only the crystallized sugar in such a state that it may be immediately shipped without any liability to loss by drainage on board the vessel, or to any decom-

position of the crystals through the injurious action of the impurities from which it has been thus freed. The molasses and impurities which have been so separated are all preserved for the still-house. Sugar thus treated commands a price in the market greater than could be obtained for the same sugar in its original state by about fifteen shillings per cwt. This, however is not all gain, as the molasses usually sold in the sugar would serve to increase, by about twenty-five per cent. the quantity brought to market. It is found too, that in the cleansing operation, the crystals of sugar are washed and lessened; this, however, is rather a fancied than a real evil; it is beauty of colour for which the grocer looks, and the goodness of the sugar for refining is by no means impaired by any artificial lessening of the grain. In newly-settled estates, and where from any cause the sugar proves dark in colour, and reluctant to part with its molasses, Mr. Innes's apparatus cannot fail of proving decidedly advantageous. We understand, that on a plantation where this invention is adopted, a steam-engine of twelve-horse power is sufficient during an ordinary day's working to furnish cane juice for six hogsheads, and to expel the molasses from four hogsheads of sugar. It is probable that some advantage might be found from the opportunity afforded by the dry condition of the sugar for making shipments in bags, which would be cheaper than casks, and should be transported at a lower rate of freight. We believe Mr. Hague's patent is adopted by some sugar bakers in France, as the first step in refining raw sugar, but in such cases the molasses is not expelled so expeditiously or effectually [illegible] the sugar is newly made.

CHAPTER XV.

ON IMPROVEMENTS IN THE DISTILLATION OF RUM.

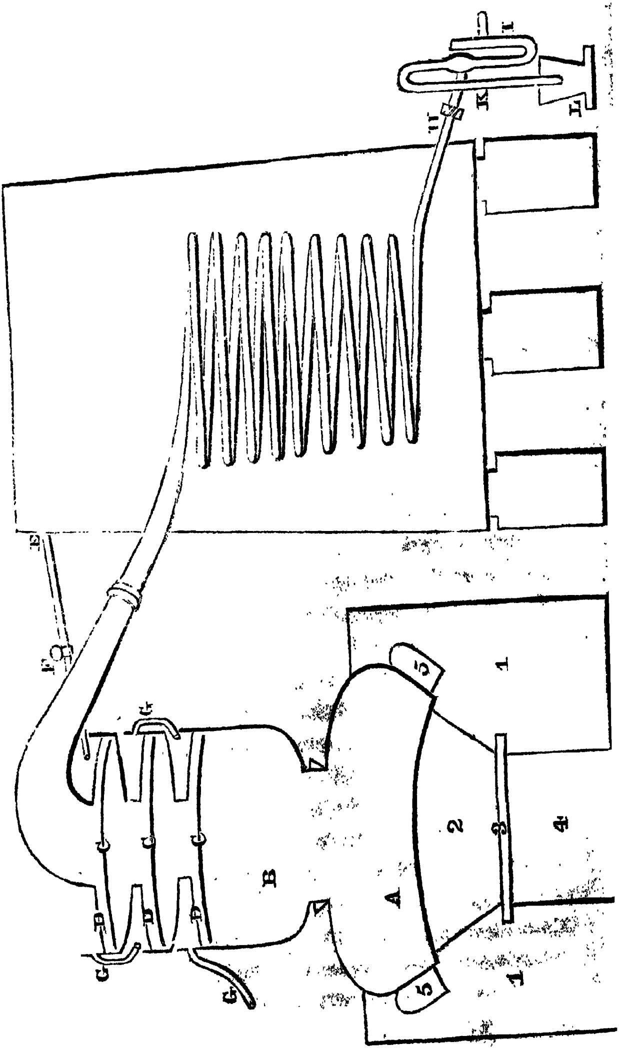
The description given in the eighth Chapter of the processes used in the distillation of rum has reference to a form of still which, until lately, was universally employed in the Colonies. The improvements which science has introduced into this important branch of the arts, are now, however, rapidly finding their way to the West Indies, where already many distilleries are conducted upon systems as enlightened as any adopted in Europe.

The objects proposed by these improvements, and in which they are found to be completely successful, are, first to effect the distillation and rectification of spirit from the wash at one and the same operation, and next to produce the rectified spirit at any degree of strength that may be desired. These improvements, while they are attended with saving of time and labour, occasion likewise some economy of fuel, and impart a greater degree of purity to the spirit. Various arrangements have been proposed and adopted for the attainment of these impor-

tant ends, but in all of them there is found a great similarity of principle, as will be seen from the following descriptions.

Among the improved stills, that which bears the earliest date is the one contrived by Mr. Corty, and manufactured by Messrs. Shears and Sons. The experience of these gentlemen has enabled them to dispense with many contrivances which originally encumbered the invention, and the following diagram, descriptive of the still now commonly constructed by them for use in the Colonies, will be found much more simple than that of Mr. Corty.

A, represents the body of the still, B, the still head, which is made very capacious in order to guard against the accident of boiling over, through mismanagement of the fire. C, C, C, are discs, or plates of copper, placed very near to the tops of the boxes D, D, D, which have a supply of water on their upper external surfaces, brought from the worm tub through the pipe E, to the top of the upper box, and thence through the pipes G, G, G, to the tops of the second and lower boxes, and, lastly, to the drain or sewer. The supply of water escaping from the side opposite to that on which it enters, occasions it to flow over the whole surface of each box, which will thus be kept at nearly an equal temperature. When the wash is made to boil, the vapour, filling the head, strikes against the colder surface of the lowest disc C, and will at first be all condensed, but when the operation has been continued sufficiently long to heat the water contained in the lower box D, beyond the boiling point of alcohol, the aqueous vapour alone


A
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pass between the edges of the disc and the side of the box to the second box, and so on to the third, whence it passes, in a highly rectified state, to the worm of the condenser. When the still is fairly in operation, it is recommended to regulate the supply of water to the boxes by means [illegible] that in the upper box it may indicate the temperature of about 145° Fahrenheit, in the second box about 150°, and in the lower box about 180°. The relative temperatures of the two lower boxes may be found to vary somewhat, but this is of no consequence, it being the heat of the water in the upper box that regulates the strength of the spirit, by allowing more or less of aqueous vapour to pass over to the condenser. The temperature here mentioned of 145°, is found, in the use of this apparatus, to condense so much of the aqueous vapour, that the spirit passes on to the condenser nearly 50 per cent. overproof, but as it is found that rum at this strength does not possess its peculiar aromatic flavour in an equal degree with spirit of from 30 to 35 per cent. overproof, it will, perhaps, be thought desirable so far to depart from the instructions of the manufacturers, as to allow the water in the upper rectifying box to acquire a higher temperature; these, however, are details which a very short experience will suffice to regulate. To the lower end of the worm a gas apparatus is affixed by a brass swivel joint screw H; the condensed spirit speedily fills the bent tube I, causing the separation of the carbonic acid gas, which passes through the pipe K, to the vessel L; this contains water at about two inches higher level than the bottom of the tube K; through this water the carbonic acid gas will escape preferably to passing through the

pass between the edges of the disc and the side of the box to the second box, and so on to the third, whence it passes, in a highly rectified state, to the worm of the condenser. When the still is fairly in operation, it is recommended to regulate the supply of water to the boxes by means of the cock F, so that in the upper box it may indicate the temperature of about 145° Fahrenheit, in the second box about 160°, and in the lower box about 180°. The relative temperatures of the two lower boxes may be found to vary somewhat, but this is of no consequence, it being the heat of the water in the upper box that regulates the strength of the spirit, by allowing more or less of aqueous vapour to pass over to the condenser. The temperature here mentioned of 145°, is found, in the use of this apparatus, to condense so much of the aqueous vapour, that the spirit passes on to the condenser nearly 50 per cent. overproof, but as it is found that rum at this strength does not possess its peculiar aromatic flavour in an equal degree with spirit of from 30 to 35 per cent. overproof, it will, perhaps, be thought desirable so far to depart from the instructions of the manufacturers, as to allow the water in the upper rectifying box to acquire a higher temperature; these, however, are details which a very short experience will suffice to regulate. To the lower end of the worm a gas apparatus is affixed by a brass swivel joint screw H; the condensed spirit speedily fills the bent tube I, causing the separation of the carbonic acid gas, which passes through the pipe K, to the vessel L; this contains water at about two inches higher level than the bottom of the tube K; through this water the carbonic acid gas will escape preferably to passing through the

bent tube I, where the resisting fluid column has a greater depth. The figures 1, 1, represent the solid masonry in which the still should be set, 2 is the fire-place, 3 the bottom plate which supports the mouth piece, 4 the ash pit, and 5, 5, side flues leading to the chimney.

Many of these stills are used in the Colonies, and especially in Tobago. We have been informed by a planter residing in that Island, that by means of one which he has on his estate, the process of distillation, which formerly was one of the greatest labour and anxiety, has been rendered of easy accomplishment; that he is enabled to work the still five times in twelve hours, thus increasing the quantity of rum beyond what the common still enabled him to make, and that the rum is so much improved in quality as to command an increased price in the Island equal to twelve and a half per cent.

Another distilling apparatus which, since the year 1825, has been brought successfully into use in the Colonies, is that patented by Mr. Winter, and manufactured by Messrs. William Pontifex, Sons, and Wood, of London. The particular arrangement of this invention will be apparent if reference is had to the engraving.

A, represents the still, B, the still head, C, the wash heater, D, the retort, E, the warm water bath, F, F, the worm, G, pipe to condense the spirituous vapour which may be generated in the wash heater; *a*, *a*, *a*, *a*, is a zig-zag apparatus passing through the warm water bath, and leading from the retort to the [illegible] I; this apparatus is very narrow, the two plates of which it is formed having a space between them of only [illegible] an inch; the sides are made flat, in order to divide the wa-

pour as much as possible, and to expose a considerable surface to the action of the warm water; *b b*, is a bent tube leading from the still to the retort, serving to regulate the quantity of fluid collected in the retort, and to preserve its level by returning to the still any that may be in excess; *c*, is a cock to discharge the whole contents of the retort into the still; *d d*, is a pipe leading from the cold water cask to the warm water bath; and *e*, is a cock to regulate the supply of cold water to the bath.

When the wash in this still is made to boil, the vapour passes into the retort, and thence through the zig-zag apparatus to the worm. It is evident that the strength at which the spirit is delivered will depend altogether upon the temperature at which the warm water bath is maintained, as, according to the lowering or raising of this temperature, more or less of the aqueous vapour will be condensed in the zig-zag, and returned into the retort. When the spirit is run off, the spent wash is removed from the still through the cock; and the contents of the wash-heater, together with the low wines collected in the retort, are transferred, already heated, to the still.

The retort is said to be useful as a means of separating from the alcoholic vapour, the essential oils which first arise in the process, and which impart an unpleasant flavour to the spirit, thus acting as a second or steam still, and tending to the greater purity of the rum.

A very satisfactory experiment has been made with this apparatus on an estate in Jamaica. 18,000 gallons of wash were divided into equal portions: 9000 gallons were distilled in the old manner, first through a wash still and then through a spirit still; the produce was 365 gallons of rum 42 per cent. overproof, and the time

occupied in the two distillations was 113 hours and 55 minutes. The second 9000 gallons were distilled in Winter's apparatus, and in 105 hours produced, at one distillation, 410 gallons of rum 52 per cent. overproof. The rum produced by this process is much purer and better flavoured than was obtained by the old system, and a considerable saving of fuel is likewise effected.

Some other plans have been proposed for effecting the same objects as are accomplished by the two stills already described, which, however, do not appear to offer any advantages over those of Corty and Winter; and the very important quality of simplicity would seem to be altogether in favour of these inventions, which demand but little more carefulness in the attendant than will suffice to keep the warm water bath at a proper temperature. Rum distilled by these improved methods, commands, from its superior quality, a preference, and consequently a higher price, proportionally to its strength, in the European markets. Being produced in a more concentrated form, it occasions likewise a considerable saving in the cost of casks, in freight and other charges.

The invention for communicating heat, patented by Beale and Porter, which has already been described in the preceding Chapter, may be advantageously used in conjunction with any form of still or apparatus, by putting a casing or jacket round the bottom of the still, and furnishing the space between the two bottoms with one of the fluid media. It would then be found impossible to communicate any empyreumatic flavour to the spirit, while the saving of fuel would alone give an adequate return for the trifling additional outlay.

In several of the West India Islands, considerable annoyance is experienced from the couch, or dog's grass, called also by the colonists, *devil's grass*. It is said that an abundant spirit may be obtained from the fresh roots of this weed, which should be cut, bruised, infused in boiling water, and then fermented with yeast. Treated in this way, Mr. Hoffman is said to have procured from it, by distillation, a spirit which equalled in purity, and was much more agreeable in flavour, than that commonly obtained from malt. The endeavour to eradicate this weed entails upon some estates a very considerable amount of labour and expense, and if, upon trial, Mr. Hoffman's statement should prove to be correct, the produce of spirit would contribute towards the payment for those labours and expenses.

The specific gravity or strength of rum is commonly ascertained in the Colonies by its capability of floating hollow bulbs of glass, which are numbered according to their weight. This method is far from being accurate, no allowance being made for variations in atmospheric temperature, which materially affect the apparent strength of spirits. When the thermometer stands at 70°, the sinking of bubble,

No. 17	indicates	41 per cent.	overproof by the hydrometer.
18	"	38	do.
20	"	27	do.
21	"	24.5	do.
22	"	19.5	do.
23	"	16	do.
24	"	11.5	do.
25	"	6.8	do.
26	"	0.5	do.
27	"	5	underproof.

CHAPTER XVI.

ON THE EAST INDIAN METHOD OF CULTURE AND MANUFACTURE.

About the year 1789, the quantity of sugar produced in the British West India Colonies was found inadequate to the demand for home consumption and for exportation, and its price in consequence rose considerably. This inconvenience was soon after much increased by a deficiency of the sugar crop in the British Islands, and a total failure of importation into Europe from the important French Colony of St. Domingo, occasioned by the first disastrous insurrection of the negroes.

These circumstances induced the Directors of the East India Company to turn their attention to this important branch of commerce; and in the year before mentioned they sent orders to Bengal for the shipment of a quantity of sugar, which, arriving in England at a time when the price was enormously high, sold with some profit. They, in consequence, applied to Parliament for a reduction of duties; this, however, was not granted; but it does not appear that this refusal pre-

vented the Company from still anxiously promoting the culture and manufacture of the sugar cane and its products in India, and we find them actively inquiring as to the capabilities of the soil, the qualities of the cane and the sugar, in every part of their large possessions.

In the year 1791, the Directors made an agreement with Lieutenant Paterson, granting him a certain portion of land, (600 bigahs of 100 cubits each,) rent free, for a term of twelve years, whereon he was to make a sugar plantation, and engaged to sell the whole of its produce on favourable terms to the Company. Since that period this branch of trade seems to have been a subject of continued interest to the company. It appears that the soil and climate of India are particularly favourable to the growth of the cane, and the testimony of several authors shows that its culture might be extended and improved in a most important degree.*

* In the Zemindaries of Peddapore and Pettapore, 700 to 1400 acres of land are annually employed for rearing sugar cane, more or less, according to the demand, or prospects of a demand, for the sugar. They could and would with pleasure, if they were certain of a market, grow and manufacture more than ten times the usual quantity, for it is very profitable, and there is abundance of very proper land.—*An account of the Hindoo Method of cultivating the Sugar Cane, &c. by Dr. Roxburgh.*

Sugar requires a rich, free soil, &c. * * * Of such land there is in this district a considerable extent, and a great part of it is now planted with this valuable article.—*Dr. Hamilton's Survey of Dinajpur, &c. in the year* 1814.

From the luxuriance and fertility of this country, I think it is amply competent to the supply of all Europe with sugar.—*Fitzmaurice's Memorial.*

From Benares to Rengpur, from the borders of Asam to those of Catac, there is scarcely a district in Bengal, or its dependent pro-

It is not our province to point out the causes which probably retard its more extensive cultivation, but it may, perhaps, be interesting to give an account of its culture as usually practised there, and of the rude manufacture of its juice by the natives.

There are several sorts of soil in which the sugar cane can be planted successfully; but it appears that the most favourable is found to be the mixture of clay with sand, similar to that called brick-mould in the West Indies. Manuring seems to be considered very important in Eastern husbandry, and the plough is in constant use in preparing the lands: in some places they plough the land from January to March, eight or ten times previously to planting in April; in other places they only give two ploughings in March. For each bigah, (about a third of an acre,) they allow one hundred bullock loads of dung and fifty of rich earth from bottoms of tanks, &c. After a heavy fall of rain the ground is again twice ploughed and harrowed. In some districts the land is ploughed sixteen, twenty, or twenty-five times, from the month of June to September. In this state the land remains till December, when a flock of sheep is placed in the field for a few days, for the sake of their manure, which is considered of singular efficacy to the growth and strength of the cane. After this the land is watered from tanks, unless it be so happily si-

vinces, wherein the sugar cane does not flourish. It thrives most especially in the provinces of Benares, Behar, Rengpur, Birbhum, Birdwan, and Mednepur; it is successfully cultivated in all, and there seem to be no other bounds to the possible production of sugar in Bengal than the limits of the demand and the consequent vend of it.—*Remarks on the Husbandry and internal Commerce of Bengal.*

tuated as to be capable of being irrigated when required. The ground so prepared is planted in January, February, or March. Smooth ridges are then raised about four inches high, varying in different districts, from one and a half to two and a half feet in distance; whilst the ground is moist the plants are placed in the ridges, at about two feet or two feet and a half from each other; they are then slightly trod into the soft ground.* Should rain not fall for five or six days afterwards, the plants are moistened round with a mixture of water and dung, and should the drought continue, the same is repeated every four or five days. Each plant will produce seven, eight, nine, or even more shoots, which are wrapped round and tied together, when about four feet high, with their own leaves. In August, pressed mustard seed, after the oil has been extracted (coil,) is put to each root, and should there be a deficiency of rain, and it is practicable, water should be let into the field till it covers the ridges, and it should not be allowed to run off for four or five days. When the plant has attained the height

* In Mysore, the ground is ploughed nine times in the forty-four days previous to planting. Then the field is divided into beds of about nine feet wide; these are divided by trenches of about fourteen inches wide, and eight deep. In every alternate trench are dug small wells about two feet deep. The water from the canal flows through all the trenches, and a quantity of it, lodging in these wells, is taken out with pots for watering the plants by the hand. Across every bed, at the distance of eighteen inches, are dug five holes about six inches in diameter and three in depth. In each of these are placed, horizontally, two cuttings of the cane, each containing three joints. These are covered slightly with earth, over which is laid some dung.—Dr. *Buchanan's Journey from Madras through Mysore, Canara, and Malabar, in* 1800.

of five feet and a half, or six feet, the plants springing from four of the original roots, (those of each bound up as before described,) are brought together and wrapped round from top to bottom. This is intended to preserve the canes from the bad effects of winds, and prevents a multiplication, or at least retards the vegetation, of the leaves, which they erroneously think draw from the cane a part of its nourishment. Young shoots which arise at and after this period are carefully removed, and given to the cattle. The ridges are now levelled, and care is always taken to bind the plants together as they shoot up, and to keep them free from weeds.

The cane is ripe in January, and rises to the height of nine, ten, eleven, or even twelve feet, according to the difference of soil, season, or attention. It is cut down with a sickle, and then stripped of its leaves. About fifteen inches of the top are cut off for shoots for the next season. After as many are taken for this purpose as are required, the rest of the tops are given to the cattle. From seven to nine thousand slips are set aside for planting each bigah (about the third of an acre.)

When first cut from the stem, they are tied in bundles of forty or fifty each, and are carefully kept moist. In a few days they put forth new leaves; they are then cleared of the old leaves, and dipped into a mixture of cow dung, pressed mustard seed, and water. A dry spot is prepared with some rich, loose mould, and a small quantity of pressed mustard seed. The plants are separately placed therein, a small quantity of earth is strewed among them, and then they are covered with leaves and grass to preserve them from heat. Ten or twelve days after this they are planted.

Much labour and attention are requisite to keep the plants during vegetation free from insects, which collect in great numbers, and if not speedily destroyed, do great mischief.

Crop time generally continues from January to March. As the juice so quickly spoils, no more canes are cut each day than can be ground in that time, and as there is, perhaps, only one mill for this purpose in a whole village, the operation goes on but slowly.

The canes appear to be subject to fewer accidents here while growing than in the West Indies. A wet season may be reckoned their worst evil, as it renders the juice very poor and unprofitable.

The precaution of tying the canes together enables them to resist a storm without much injury. At intervals of a few years, a species of worm or caterpillar commits great devastations among the canes, and, what is worse, the disease, when it happens, is commonly general, few fields escaping. Sometimes this evil is so great as to destroy a sixth or an eighth part of the crop.

Several different kinds of canes are cultivated in the East Indies. That called by the natives *cadjoolee* is purple-coloured; it yields a sweeter and richer juice than the yellow or light-coloured, but in less quantities, and it is harder to press. It flourishes best in a dry soil. This is principally cultivated in Beerbhoom and in Radnagore, and there are some about Santipore. It grows also near Calcutta. Persons who have been West India planters do not know it as a West India cane. The *pooree* is another sort; it is a light-coloured yellow

inclining to white, but assumes a deeper yellow when it ripens, or the soil is rich. This is thought to be the same description which grows in the West Indies. It is softer and more juicy than the *cadjoolee*, but the juice is less rich, and produces sugar less strong. To make an equal product of sugar from this, as from the first, it requires seven parts of this to six of the former. Much of this kind of cane is eaten raw.

The third sort is *cullerah;* this cane grows in swampy grounds, is light-coloured, and grows to a great height. Its juice is more watery and yields a weaker sugar than the *cadjoolee*. There are other sorts, called by the natives in the different districts *punsaree*, *reonda*, *mungoo*, *newar*, and *kiwahce;* most probably some of these are only different names for those already described. Dr. Buchanan calls the two kinds of cane which he found cultivated in Mysore, *restali* and *puttaputti*. The first is the original sugar cane of the country, the latter was introduced from Arcot. The natives extract crystallized sugar only from the latter. Dr. Buchanan observed at Bangalore two other kinds in cultivation besides these two, the *maracabo* and *cuttaycabo;* these are very small, seldom exceeding the thickness of the little finger, and very unproductive in juice; they are, however, cultivated, because they require little water.

The mills of India appear to be very simple in their structure. Those accustomed to the large mills of the Western Colonies would treat these simple engines with great disdain, but they completely, though slowly, express the juice, and though not so rapid in their effects, their trifling cost, and the advantage of being able to

move them from field to field, may, perhaps, compensate, in some degree, for their tardy performance. Iron cylinders have been brought from England, and mills, worked in the West Indian manner with horses or cattle, have been set up. But it is said that the expense attending them caused their use to be dropped. It was found that a number of Bengal mills, sufficient to express the same quantity of juice, did the business cheaper than the West Indian mill.

Near Calcutta the mills used are simply two small wooden cylinders grooved, placed horizontally in a frame close to each other, and turned by two men with levers and cross-bar handles. The juice is received in a pan placed underneath. In some other parts the mill is merely a large wooden or stone mortar, with a rolling pestle turned by oxen; the juice runs through a small aperture to the lower part of the vessel, at the side of which there is an opening and lip from which the juice runs into a vessel sunk into the ground to receive it. It is estimated that one of these mills will produce equal to seventy-five or eighty pounds of sugar a day; and the West Indian planter will smile to be told, that, with twelve oxen and eight men working twelve hours a day, it takes twelve days, working with one of these mills, to clear half an acre.

The cane juice is boiled by the cultivator to an inspissated state. There are two ways of performing this. The juice, taken out of the vessel at the foot of the mill, is conveyed in earthen pots either to a large iron boiler set over a furnace in a house or shed adjoining, or in earthen pots placed on a platform, under which a brisk fire is kindled, and fed by the dry squeezed canes.

It remains in these pots in a boiling state for four or five hours, during which time it is carefully scummed with a wooden ladle, and cleared from the gross feculencies. The greater the attention which is paid to this process, the more, of course, is its quality improved, and its quantity lessened. The sufficiency of the boiling is ascertained by the liquor falling clear, drop by drop, from the ladle. If thick and in a body, it is over or under boiled. In both cases the sugar will have a small grain, and in the latter it will have a bitter taste. This syrup is put, after boiling, into large jars, and a little of it is rubbed over their edges, which is thought to promote the formation of the grain. It is in this state sold to the sugar boiler, under the denomination of *goor*.

In Benares, the natives boil the juice in flat iron pans of small capacity, and continue stirring and scumming the liquor with wooden ladles; if they wish to make it very pure, they add some milk. When the grain appears formed, the pan is taken from the fire and placed on the ground, where the liquor is again well stirred and agitated with the ladle till it cools, and forms into a coarse sugar, which they scrape together, and lay out on cane leaves or cloths to dry. This is now called *bhelee*. It is used by the natives in its coarse state, or sold to the sugar boilers to be farther refined. They have likewise another method of preparing the juice. As it is brought from the mills, it is kept hot during the day to prevent fermentation. In the evening it is emptied into large earthen vessels placed on the ground, where it remains till the following morning. The boiling house is fitted up with a large iron boiler, and four or five earthen ones connected with it, all receiving heat

from one fire, the iron boiler being placed nearest the fire place. Early in the morning the juice is put into these vessels, and a fire lighted under them; while it is heating, it is clarified with the juice of a plant called doolah.* It is constantly scummed while it simmers; the heat is then increased, and as the aqueous parts evaporate in the different boilers, it is laded from one to the other onward to the iron boiler, so as always to keep this full of the liquor, which is made to boil briskly, till brought to a proper consistency, when it is put in earthen vessels, and beaten with a thick stick till cool, or properly grained. This is called *raab*, and is either used in this state, or sold to the sugar boiler. These three different kinds are known under the general name of *jaggry*.

From these crude preparations, the boiler attains, by different processes, four or five other varieties.

To refine the *goor* into *chence*, or the sugar which is generally exported, the following process is used.

About twelve maunds of *goor* are put into a strong, close bag, made of hemp twine, which is suspended over a reservoir to receive the syrup which oozes through, and from which sweetmeats are made. The day after its suspension it is encompassed by three pair of pressing boards, tied very tight. As the liquor oozes from the bags, these boards are drawn closer. It remains thus five days, when the remaining *goor* is taken out. The bag being well washed, the *goor* is again put into it, after previously being well mixed with water, about a quart

* A species of mallow, which is planted among the sugar canes for that purpose.

to each maund, and the pressing boards are again applied: in this state it continues for five days longer. A third time it undergoes this process, and remains for ten or twelve days suspended. When syrup is no longer observed to ooze from the bag, it is considered as ready for boiling into sugar.

This is the process at Soonamooky; in other parts they are not so elaborate in their preparations. The operation of the bag sometimes takes only three days; no water is added, and the thick *goor* remaining in the bag is boiled in a cauldron with a mixture of water, milk, chunam, and *kchar*, (the leys of plantain tree ashes.)

The boiling is performed over a deep hole somewhat like a furnace; earthen or iron pots are used, varying in capacity; to every maund of *goor* fifteen quarts of water are added. The fuel most in request is dried leaves, as they burn very fiercely and make no smoke. A man constantly watches the fire and feeds it most cautiously, for if the flame rises too high the liquor almost instantly boils over; indeed, such very great caution is necessary, that the leaves are thrown in almost singly. The liquor remains in a boiling state for about an hour; it is constantly scummed, and when it rises too high, milk, diluted with water, is thrown in, which causes it to subside. When boiled sufficiently, it is strained through a cloth, and put into a long jar. It then undergoes another boiling with cold milk and water sprinkled in it; in general this second boiling is completed in half an hour. To ascertain when it is sufficiently concentrated, a little is taken between the finger and thumb, in the same manner as in the West Indies. If

it easily forms into grain, it has been boiled enough; if it adheres to the fingers it has been boiled too much; if it will not granulate, it must be concentrated still farther. When the boiling is completed the sugar is put into earthen jars and allowed two days to cool and harden; after which wet leaves called pattha* are placed on the top, and a hole is made at the bottom, which is plugged up with soolah, (a species of rush,) through which the syrup drains from the sugar. In general, the draining is completed in five days. The syrup is made into sweetmeats, or exported. In about fifteen days the sugar is considered sufficiently forward to be taken out of the pots, when it is laid in the sun to dry, after which it is ready for sale. About two inches from the top is the best and whitest, thence it gradually becomes browner, till, quite at the bottom it is little better than the *cotterah*, or syrup, which has drained from it. In some districts the whole of this is mixed up together for sale, in others the curing is conducted more carefully. In about nineteen or twenty days after the sugar has been first put into the jars, it is scraped off the top with a knife as far as it is properly cleansed and whitened by the weeds. This first sugar is the finest and best manufactured. Another coating of weeds is laid over the sugar which remains in the jars, and being removed in about eight days, the upper part of the sugar is again scraped off. The remainder is again covered

* This is a particular weed which grows in tanks and rivers. It is supposed to contain an alkali, which assists in purifying the sugar. It being laid over the tops of the jars wet and fresh from the water, a layer of earth is put over it, gently to press its moisture into the sugar. It is called by other names in different parts of India.

and scraped off in about five or six days. This third scraping generally completes the process, though it is often necessary to give it a fourth coating.

Chenee is made from the bhelee in a similar manner, the preparation for boiling being necessarily different. As the bhelee is sold to the manufacturers in large lumps or balls, the process of the bag is not required. These lumps are dissolved in water to a syrup of proper consistency, and then while slowly boiling it is sprinkled with milk and water, by means of a rag tied to the end of a rod, and scummed as in the former process.

The chenee made from raab is first made into another product called *khaur*, or *shuckur*. The raab is tied in a piece of doubled cloth about five yards long, and placed on two sticks over an earthen vessel, where it remains about fifteen days to allow the molasses to drain from it; this cloth is then opened, and the sugar is spread on a piece of coarse canvass in the sun, where it is trodden by people with their naked feet, till all the lumps are broken, and the grain of the sugar appears white and smooth, which will, in a great measure, be in proportion to the time and labour bestowed on it. This product is used by the confectioners, and is said to be quite equal in quality to the muscovado sugar of the West Indies; the treading operation does not certainly render it as inviting to the European taste.

The shuckur is made into *chenee* exactly in the same manner as the *bhelee*.

Another kind of sugar is made from the *goor*, not so refined as the *chenee*, called *dowloa;* it is prepared as follows. *Goor* is put into baskets very closely woven, and kept in them till about one-fourth part has drained

gradually into the vessels placed underneath. What remains in the baskets, being an impure dark coloured damp sugar, is removed into other baskets of a rather more open texture, and left to strain through for three or four days exposed to the air; the baskets are then covered with the pattha and kept so for five or six days, fresh weeds being applied as the old ones become dry; during this time the molasses contained in the sugar continues to drip through the bottoms of the baskets into other vessels. After this process the sugar remaining in the baskets appears to be hard and dry, and is scraped off by an iron instrument. If the sugar towards the middle or the bottom of the basket should appear damp and not sufficiently cleared of the molasses, fresh leaves are again applied, and this operation is continued till the sugar becomes sufficiently dry.

The *boora* is made from this, and sometimes it is used in making the best *chenee*.

Boora is made by mixing twelve parts of *dowloa* with three parts of water. This mixture is subjected to a strong heat, and during the boiling, which is kept up for an hour and a half, a mixture of milk and water is sprinkled into it, and it is very carefully scummed. The pan is then taken off the fire and the hot syrup is strained through a cloth into smaller pans, in which it is again sprinkled with milk and water, scummed and boiled for about another hour, when it is usually sufficiently boiled; this is ascertained by the thickness of the syrup, and from no scum rising. The pan is then taken off the fire, and the hot syrup is stirred with a large iron spoon until it cools into a solid mass, when

it is laid on a smooth board and broken into powder with rollers; it is then ready for packing.

In a manufactory at Atchipore, which appears to be conducted by, or to be the property of Europeans, the same process is carried on as we have already described, with the West India system somewhat engrafted on it. There are copper vessels for boiling; quick lime is used as a temper mixed with the milk and water, and instead of the pattha, clay is put on the sugar to bleach it. It does not appear that there is any material difference occasioned in the quality or quantity of the sugar by the use of clay. The only advantage it possesses is, that two coats of clay will usually be as beneficial as four applications of the pattha.

In Dr. Hamilton's Statistical Survey of Dinajpur and other places, from 1809 to 1814, we find a particular account of the buildings and utensils requisite in manufacturing sugar. The process which he describes is very similar to that of which we have just given an account. After going so much into detail, it will, perhaps, be tedious to give a particular description of every building and the dimensions of each vessel; we will, therefore, merely notice the arrangement which is in any way different from what we have already described.

The boiler is sunk into a cylindrical cavity in the ground, which serves as a fire-place, so that its edge is just above the floor of the boiling house. The fuel is thrown in by an aperture close to one side of the boiler, and the smoke escapes by a horizontal chimney, which passes out on the opposite side of the hut. Some manufacturers have only one boiler, others as many as four:

but each boiler has a separate hut, in one end of which is some spare fuel, and in the other end some bamboo stages which support cloth strainers that are used in the operation. This hut is about thirty-six feet long and fifteen broad; it has mud walls about nine feet high, its floor is about a foot and a half from the ground. Two other houses are required for each boiler, one for draining the molasses from the *goor* previously to boiling, the other for curing the sugar.

The time requisite for making *goor* into *chence* where the process is most carefully performed is nearly two months.

The drainings from the *chenee*, called *maht* or *maut*, are often boiled over again with an alkaline ley, and produce a coarse kind of sugar. The drainings from the *goor*, called *cootrah*, is used in sweetmeats by the poorer class of people, and a great deal is consumed mixed up with parched rice and other grain. Maut is frequently mixed with tobacco and smoked; and from the multitude of people who smoke, no inconsiderable portion must be used in that manner.

The natives say it adds greatly to the strength of cement, and if not forbidden, constantly use it in their pucka work.*

Cootrah goor is used in the distilleries; great quantities of spirits are distilled from it, and sold very cheap by the natives. Their apparatus consists of earthen

* It is said that the pucka masonry erected in the proper Bengal manner is wonderfully strong and durable, and equal, perhaps, superior to that of the ancients. The pucka masonry which the Europeans in Bengal adopted for cheapness, though good compared with London masonry, is much inferior to the pucka of the natives.

vessels and a bamboo for the pipe or neck, which answers so well that some Europeans adopt it.

Fitzmaurice, in the memorial addressed by him to the East India directors in 1793, gives an account of the inefficient machinery and utensils of the sugar cultivator, and the consequent deterioration of the juice. He observes that the mill grinds so extremely slow, that the juice acquires a degree of acidity which destroys not only a considerable portion of the saccharine particles, but contaminates the whole remaining body; after boiling, the juice is put into close jars and fermented a second time, while it is being conveyed on bullocks, or by water, perhaps a hundred miles, to be sold to the sugar boiler. From this *goor* the refiner obtains a fourth of its weight in sugar, "whereas," he says, "the first manufacturer might, with the same fuel and labour, augment the quantity sixty per cent. and improve the quality."

We believe the author ascertained this fact by actual experiment. It certainly does appear to be the most rational and economical method to complete the manufacture at once, but whether arising from the inveterate prejudices of the Hindoos, or from some political or local causes of which we are not competent judges, the practice of which he complains appears to continue to the present day, and the farmer who cultivates the cane and converts its juice into *goor* is distinct from the sugar boiler, who refines it into sugar. We have not been able to learn that any Europeans have successfully established sugar plantations and manufactories combined, but have heard of several who have made and abandoned the attempt.

In some parts and in favourable soils and situations, the cane seems to yield abundantly. There are various statements from many different districts of the quantities and proportions produced. According to Dr. Buchanan the produce of an acre of land near Bangalore amounts to 70,000 ripe canes, which yield 140 maunds of *goor*, or 30 cwt. of this rude material; this is capable of being made into 15 cwt. of raw sugar.

In a letter from a Bengal planter we find a statement of the produce of nine different provinces, averaging 18 cwt. 3 qrs. 22 lbs. per acre of muscovado sugar, the sugar being computed as one-half the quantity of *goor*; but in this proportion the sugar must be of very inferior quality, as, on consulting other very respectable authorities, we find that three to four parts of *goor* are uniformly required to make one part of *chenee*.

In a very circumstantial detail of the culture and manufacture of sugar in the Masulipatam Circar, we find it stated, that a vissum, or 72,000 square feet of ground, were found to produce 85,140 canes, being in the proportion of 51,405 per acre. These canes yielded, on expression, 41,412 lbs. of juice, which produced 300 maunds or 7200 lbs. of jaggry; this, by a further process, was reduced to

cwt:	qrs:	lbs:	
19	3	11	of sugar,
16	1	16	of inferior jaggry,
9	3	15	of syrup.

The proportion per acre being, consequently,

cwt:	qrs.	lbs.	
12	0	14	of sugar,
9	3	18	of inferior jaggry,
5	3	25	of syrup.

It thus appears that the produce in sugar does not quite reach to one-third the weight of goor or jaggry.

The *goor* obtained from cane juice varies in different soils or seasons from a fourth to an eighth or ninth part of its quantity, the average being about five and a half parts of juice to one part of *goor*.

It appears from this statement, upon the correctness of which reliance may be placed, that in every particular connected with the manufacture of sugar, our West Indian Colonists are very greatly in advance of the agriculturists of Hindostan, whose processes are at once less productive and more laborious than those employed in the West Indies: disadvantages which can only be met by the comparative cheapness of labour, arising out of the state of oppression and abject poverty in which the miserable peasantry of India are kept.

Dr. Buchanan, in the account of his journey through Mysore, Canara, and Malabar, in the year 1800, tells us that at Chinapatam, there resides a family who possess the art of making very fine white sugar by a process which has always been kept as a profound secret, and transmitted for many generations, the head of the house instructing his successor a short time only before his death. The sugar thus made is monopolized by the court, who are unwilling to allow their subjects to partake of the same luxury. This family are furnished with cane juice, and are paid a very liberal price for the manufactured article, enjoying likewise, as officers of the court, a village rent free. This miserable and short-sighted jealousy is a part of the system under which the wretched inhabitants of India have always been kept back by the arbitrary governments of Hindostan in the

march of improvement, and may in a great measure have afforded grounds for the opinion so generally entertained of the immutability of Indian habits and institutions. Dr. Buchanan examined the head of this family of sugar boilers, as to the manner in which his operations were conducted; but, as might naturally be expected, found a reluctance to afford information, and had reason to think that his answers were given with the intention of misleading.

From the same authority, we learn that the sugar-candy made in the country round Chica Balapura is equal to that made in China, and that the clayed sugar is very white and fine. The superior process employed here is likewise kept secret, having been introduced by the Sultan at Seringapatam. At the time Dr. Buchanan wrote, the manufacture was conducted by two Brahmins, who sold their commodity on the spot, at a higher price than that at which the Chinese sugar-candy might be procured in Seringapatam. The fine white soft sugar of this district is, by some process, also kept secret, made up into a kind of paste, which is moulded in various forms, and hardened into cakes, which are presented to guests at marriage festivals and on other great occasions.

In the Ganjam district about Aska and Barampore, the natives make both sugar and sugar-candy of very excellent quality, but only in limited quantities. The sugar is made in the form of loaves, the grain is said to be large, and the colour equal to English single refined sugar. The sugar-candy is represented as of the most superior quality. The processes employed in the manufacture are exceedingly simple, but very tedious, and

can only therefore be adopted where labour is extremely cheap. The mill is of the wooden mortar and pestle kind already described, and the juice, which is received in an earthen pot, is strained, and quick lime, in the proportion of half an ounce to a gallon, is added. It is then boiled for a considerable time in earthen vessels, and when, on rubbing the syrup between the fingers, it is found to have a tenacious consistency, it is taken off the fire and put into pots, where it is kept for many months. A small hole is then opened in the bottom of these pots, through which the syrup drains. When this draining ceases, the sugar is taken from the pots and placed in shallow bamboo baskets, to promote a further exudation of syrup; it is then put into cloths and squeezed, a little water being occasionally added, to promote the separation of the syrup. After this the sugar is dissolved in water and boiled in wide-mouthed pots, holding each about three quarts; the fire is not very violently urged, and from time to time a little milk diluted with water is stirred in to clarify the sugar, the religion of the people forbidding them to use eggs for that purpose; the scum, as it is thrown up, is removed, and when sufficiently concentrated, which is ascertained by the common test of the finger and thumb, the sugar is poured into small pots with wide mouths, to cool and crystallize; after a time a small hole is opened to drain off the syrup; the outsides of the pots are now covered with cow-dung, and for the purpose of whitening the sugar, pattha is placed on the top and renewed every day for five or six days. The sugar must then be thoroughly dried and kept for use. To make sugar-candy, this whitened sugar must be again dissolved in water,

and boiled as before described, adding one-sixth part of milk. When the boiling is considered sufficient, the syrup is put into pots as before, with thin slices of bamboo or some dried date leaves, to promote the proper crystallization of the mass.

Sugar is imported into Europe from India in bags. It has been proposed to pack it in chests, as diminishing the chances of damage and the loss by waste during the voyage, but it appears that chests would be less convenient for transport to the port of shipment than bags, which can be thrown across the neck of a bullock and more readily transferred from one conveyance to another. If, indeed, the sugar has been properly freed from molasses and dried, bags would seem otherwise preferable, from their comparative cheapness. Hogsheads would be even less desirable than chests, as they would occupy more space in the ship in proportion to their contents, and would, consequently, be burthened with a higher rate of freight.

There is a great want of uniformity in the weights used in India. The maund of one province is a very different quantity from the maund of another province; and frequently in the same place, as in Calcutta, maunds are of two descriptions: the *factory maund* being equal to 74 lbs. 10 oz. 10 dr., while the *bazar maund* is 82 lbs. 2 oz. avoirdupoise. At Vezigapatam and elsewhere, the same denomination of weight is only 24 or 25 English pounds.

CHAPTER XVII.

ON THE CULTURE AND MANUFACTURE OF SUGAR IN VARIOUS COUNTRIES.

The cultivation of the sugar cane appearing to have much increased of late years in Java, some account of its culture and the manufacture of sugar in that Island may not be uninteresting. We propose, therefore, to give such information as we have been able to extract from various works which we have consulted on the subject.

From the voyages of Rear Admiral Stavorinus, so far back as 1768, we learn that sugar was then produced in large quantities in Java. Thirteen millions of pounds were manufactured in that year, (1768,) in the province of Jaccatra alone. The greater number of sugar works were then, and are still, kept and carried on by Chinese.

In the year 1710, there were one hundred and thirty-one sugar plantations in Jaccatra; their number, however, decreased considerably before, during, and after the war in Java, so that at the end of December, 1750, there were no more than seventy-seven left, and of these only sixty-six were in a condition to be worked.

Sir Thomas Stamford Raffles, the enlightened author of the History of Java, informs us, that of the sugar cane, or according to the native term *tébu*, the name by which it is designated, not only in Java, but throughout the Archipelago, there are several varieties. The dark purple cane, which displays the greatest luxuriance, and shoots to the length of ten feet, is the most highly prized. By the Javans, the sugar cane is only cultivated to be eaten in an unprepared state as a nourishing sweetmeat. They are unacquainted with any artificial method of expressing from it the saccharine juice, and consequently with the first material part of the process by which it is manufactured into sugar. Satisfied with the nourishment or gratification which they procure from the plant, as nature presents it, they leave the complicated process to be conducted exclusively by the Chinese.

The cane, as in the West Indies, is propagated by cuttings of about a foot and a half long, which are inserted in the ground, in an upright direction, previously to the setting in of the rains. The Chinese occasionally use oil cake for enriching the lands; but where the plant is only raised for consumption in its fresh state, no manure whatever is thought requisite, and a good soil, without such preparation, will yield three or four crops in succession.

The cane is extensively cultivated for the juice in the vicinity of Batavia, where there are numerous manufactories principally owned by the Chinese.

It is also cultivated for this purpose in considerable tracts at Japara, Pasuruan, and partially in other districts of the Eastern provinces, where mills are established for expressing its juice. Previous to the dis-

turbances in Cheribon, sugar was likewise manufactured there in considerable quantities, and furnished an important article of export from that district.

There are considerable sugar estates near Batavia, the proprietors of which are generally rich Dutchmen, who have built on them substantial works. These estates, each of which consists of 300 or more acres, are rented by Chinese, who reside on the properties, and superintend their management; they, however, divide the land into parcels of fifty or sixty acres, which they sublet to free men, on condition that they shall be planted in canes, and they receive as rent so much for every pecul, or 133⅓ lbs. of sugar produced. The superintendent collects people from the adjacent villages to take off his crop. One set of task-men, with their carts and buffaloes, cut the canes, carry them to the mill, and grind them; a second set boil the juice; a third clay and basket the sugar for market, at so much per pecul: thus the renter knows with certainty what every pecul will cost him. He is at no unnecessary expense for labour, for when the crop is over, the task-men go home, and for seven months in the year there only remain on the estate the cane planters preparing the next crop. By dividing the labour, it is cheaper and better done. The price of common labour is from 9*d.* to 10*d.* per day; but the task-men gain considerably more, not only from extra work, but because they are considered as artists in their several branches.

They do not make spirits on the sugar estates; the molasses and scummings are sent for sale to Batavia, where the proprietor of one distillery may buy the produce of a hundred estates. It is said to be a great saving

in the cost of manufacturing the spirit not to have a separate distillery for each estate.*

Though the sugar cane for the consumption of the natives, in its unmanufactured state, may be cultivated in any season, yet, when it is intended for the manufacture of sugar, it is planted in July and August, and cut in May and June. Two and sometimes three rattoon crops are taken. It is usually cultivated in dry arable lands, of some little elevation, and never in the finest soils, which are reserved exclusively for rice. A rich dark loam yields cane which is most productive in sugar. A soil in some measure sandy, and in a slight degree of a gravelly nature, affords sugar of the whitest and best quality. In the western districts of Java, oil cake and other kinds of manure are used; but in the more fertile eastern districts no manure whatever is employed, but after yielding three successive crops, it is then the practice, as land is plenty, to allow the ground a fallow for two seasons.†

The cane is cultivated extremely well at Batavia. The hoe is scarcely used; the lands are well ploughed by a light plough, with a single buffalo, a drill is then ploughed, and a person furnished with two baskets of cane plants, which he suspends to a stick across his shoulders, drops the plants into the furrow, and as he places each he covers the earth over it with his feet. Young canes are often ploughed as a weeding, and the hoe is used to weed round the plant when very young;

* Botham's Observations on the Mode of cultivating a Sugar Plantation in the East Indies, &c.

† Crawford's History of the Indian Archipelago, 1820.

but of this there is little need if the land has been sufficiently ploughed. When the cane is ready to be earthed up, the space between the rows is ploughed deep, the cane tops tied up, and an instrument like a shovel, with teeth at the bottom, a spade handle and two cords fixed to the body of the shovel, ending by a wooden handle for a purchase, is used by two persons to earth up the cane, the strongest holding the handle of the shovel, pressing it into the ploughed earth, while the other on the opposite side of the plant, by a jerk of the cord, draws up to the plant all the earth that the plough had loosened. Two persons with this instrument will earth up more canes in the day than ten negroes with hoes. The canes in India are much higher earthed than in the West Indies; in moist soils they, with little labour, earth them as high as the knee, at once making a dry bed for canes and a drain for the water.

The improvement in making the cane into sugar at Batavia keeps pace with that in its culture. Evaporation being in proportion to the surface, their boilers have as much of it as possible. The cane juice is tempered and boiled to a syrup, it is then thrown into vats, which hold one boiling, then sprinkled with water to subside its foul parts; after standing six hours it is let off by three pegs, at different heights, into a copper with one fire; it is there tempered again, and reduced to sugar by a gentle fire; it granulates, and the boiler, dipping a wand into the copper, strikes it on the side, drops the sugar remaining on it into a cup of water, scrapes it up with his thumb nail, and then judges to a nicety if the sugar be properly boiled. The vats are placed all at the left end of a set of coppers. After running off

all that is clear for boiling, the rest is strained on the outside of the boiling house; what is fine is reboiled for sugar, and the lees are kept for distilling.

The sugar is clayed in the same manner as in the West Indies.

The cane trash is not carried into sheds, but is laid out immediately to dry, then made into faggots, and considered quite ready for fuel.*

The size of the works may be estimated from the quantity of sugar manufactured by them, which is commonly from 950 to 2400 cwt. in five weeks, the usual duration of the manufacturing season.

An English acre of cane in land of middling quality, cultivated without manure, produces, in Java, 1285 lbs. of clayed sugar. The best lands will give, on an average, 1815 lbs.†

It is estimated that good clayed sugar may be manufactured at Java at 8*s.* 4*d.* per cwt. The European merchants, in 1820, contracted with the planters at the following rates. For the best white sugar, from five to six and a half dollars, (from 22*s.* 6*d.* to 29*s.* 3*d.*) per pecul, or 136 lbs.; and for the brown from four to four and a half dollars, (18*s.* to 20*s.* 3*d.*) per pecul. It is usually sold to the exporter for about eight dollars the white, and six or seven the brown. These high prices, and a

* Botham's Observations, &c.

† Mr. Crawford states that rich cane juice yields 31½ per cent. of sugar, middling 25, and the worst 20⅝, or an average of all 25 per cent. He must have been misinformed on the subject, as this proportion is totally at variance, and very much beyond any that has been ascertained in the West or East Indies.

free trade in the commodity, have been, within the last few years, the causes of an immense increase in the culture of the sugar cane.

The quantity of sugar made in Java seems to depend almost entirely on the demand, and is likely at all times to equal it, few countries affording equal advantages for its manufacture.

By an official statement of the sugar manufactured at Batavia and the various residences of the Island of Java from the year 1779 to the year 1808, it appears that

In 1779,	it was	30,131 peculs.
1800,	...	106,513
1801,	...	107,498
1808,	...	94,903
1818,	...	200,000

In 1813, the quantity of sugar produced in the central districts was only 10,000 peculs, or 12,142 cwt. In 1818, it had increased six-fold, and was 60,000 peculs, or 72,857 cwt. The quantity produced in the western districts was, at the last period, 120,000 peculs, or 145,714 cwt., and in the eastern extremity of the Island 20,000 peculs, or 24,285 cwt., making in all 200,000 peculs, or 242,857 cwt.

The quality of Java sugar will be best understood by comparing it with other sugar in the market where it is best known. When a pound of Java sugar, mixed brown and white, sells in the market of Rotterdam for 10½ groats, Bengal sugar sells for 9 groats, British West India 9½, Surinam 9¼, Brazil 10, Havana 14, and Manilla 10 groats. It may be observed that the qualities of the sugar from Manilla, Java, and Brazil, are nearly equal.

The manufacture of sugar was formerly carried on to a considerable extent at Bencoolen, a settlement in the Island of Sumatra.

It was attempted, in 1820, to revive this branch of commerce, and with sanguine hopes of success; we have not, however, been able to learn whether, at the present day, it is carried on to any great extent. It is stated that good marketable sugar was manufactured there at four and five dollars per pecul.

The sugar cane is very generally cultivated in Sumatra, but more frequently for the sake of chewing the juicy reed than for the manufacture of sugar. In the southern parts of the Island, particularly in the district of Manna, every village is provided with two or three machines, of a peculiar construction for squeezing the canes, but the inhabitants are content with boiling the juice to the consistency of syrup.*

The legislature, having from the 5th day of July, in the year 1825, allowed the importation of sugar from the Mauritius at the same rate of duty as that levied on West India sugar, instead of the higher rate previously imposed, this abatement has given a very considerable impulse to the settling of sugar estates in that Island. Previous to this concession, Mauritius sugar was classed in the public records, together with that imported from our East Indian dependencies, and we have, therefore, no accurate means for ascertaining the amount of shipments made to Great Britain. Since that

* Marsden's History of Sumatra.

time, as might be expected, the shipments have been very materially augmented.

The sugar planters of this Colony are mostly among the old French settlers, many of them men of considerable intelligence, and now that encouragement is held out to them, they have shown every willingness to adopt improvements, the facilities for which are liberally afforded by their English correspondents. Within the last very few years, a great number of steam-engines and improved mills have been imported. These latter are all with horizontal cylinders, which it is estimated in the Island, will give ten per cent. more juice from the same canes, than mills with vertical rollers.

Some considerable degree of apprehension has been excited in the minds of the English West India planters, lest the increased importation of Mauritius sugar should go forward in an equal ratio, so as materially to affect their interests; but we believe it will be found upon inquiry, that there exists a limit to this augmentation in the state of the labouring population of the Island; the newly-settled sugar estates are, of necessity, cultivated at the expense of other branches of agriculture, no farther importation of slaves being legally practicable.

The cane now cultivated was introduced into the Island from Java, and the average produce of sugar to the acre is said to amount to 2000 lbs. In virgin land of the best quality, it is even stated that above 5000 lbs. per acre of sugar are obtained, but this produce is materially lessened the second year; and when the land has been cropped for several years in succession, the quantity is frequently reduced to 1100 or 1200 lbs. per acre.

Very little manure has yet been applied to the lands, but it may be expected that when the soil is somewhat exhausted by successive crops of canes, the necessity and advantages of manuring will lead the planters to give more attention to this branch of agriculture. The coral reefs which surround the Island would furnish lime in sufficient abundance. The land is so full of rocks and stones, that it would not be possible to use the plough. These stones are supposed to be of volcanic origin, and it is said that by their gradual decomposition, the soil is greatly benefited, while they serve as natural barriers to prevent the washing away of the mould by the floods. It appears singular, that in the more rocky soils the annual returns are the most abundant; such land, from the first plant canes, will yield above 5000 lbs. per acre, and the rattoons, which, with little or no manure, may be cut for seven or eight years, will return, progressively, less, until the last year's produce will not exceed 1500 lbs. the acre. The poorer soils will only give 2000 lbs. of sugar, as the produce per acre of first cuttings; and rattoons can only be profitably cut for two seasons, on the second of which the sugar made will not exceed 1000 lbs. the acre.

The vessels employed by the Mauritius planters for clarifying and concentrating the cane liquor, are all made of cast iron, and in general the processes used by them are very similar to those practised in the French West India Islands.

In one respect, however, they have borrowed from the example of the Hindoo and Chinese planters, and do not always unite the art of manufacturing sugar to the culture of the cane, it being very usual for one set

of works to manufacture the sugar of several surrounding properties. This matter is arranged sometimes by the manufacturer purchasing the canes, which are then cut and delivered to him at his works; or more commonly by his receiving the canes and returning to the grower a certain proportion, previously agreed upon, of their produce when manufactured, retaining the rest, in return for his expenses, and as payment for his skill and labour, and for the use of his machinery and utensils.

If the canes are delivered by the grower at the mill, the proportion of sugar returned to him is two-thirds of the quantity manufactured; but this proportion is reduced to one-half, if the manufacturer incurs the labour and expense of conveying the canes from the plantation. In some cases the planter likewise receives a proportion of the coarser products and of the rum; but this is not the general custom, and it is evident that these minutiæ must be subjects of bargain and arrangement between the planter and the manufacturer; the difference in the divisions of the produce being the medium for equalizing the greater or less facilities of conveyance to the works.

The clarification of the cane juice is effected by means of lime, which, however, is not added until the cane liquor has reached the second or third boiler, and when, consequently, much of the scum has already been removed. It is usual to apply one pound of lime to every 240 gallons of juice, but this, of course, depends upon the maturity of the cane when cut, the season, and the nature of the soil; and it appears that this part of the process is only entrusted to careful and competent persons. The sugar is *skipped* into shallow wooden boxes

to cool, and from them is transferred to other wooden boxes in the curing house, or *purgerie*, until it is sufficiently drained. It is then spread upon wooden platforms in the air, and when perfectly dry is put into bags for exportation.

These bags are made of the long leaves of the vacoa tree; two bags are used, one being put inside the other; they contain about one hundred weight and a quarter of sugar, and the whole expense of the two bags, filling and sewing up, does not exceed one shilling.

Although the sugar cane is much cultivated in China, it does not appear that any of the plantations are of sufficient extent to have a separate manufacturing apparatus. This branch is quite distinct from the cultivation: the sugar boiler travels about from one plantation to another, with all the necessary machinery and utensils for expressing the juice and manufacturing it into sugar.

It is not a matter of any difficulty thus to transport the apparatus, as there are but few plantations which are not easily accessible by water carriage. A temporary building is formed of a few bamboo poles and mats, under which are erected the mill and boilers, which very much resemble those usually employed in India. The itinerant sugar manufacturer endeavours to make his agreement with several planters, so that his works being placed in some central spot, may serve them all without shifting.

A great deal of sugar is manufactured in Cochin China; one method used there produces much purer sugar than that usually practised. After boiling the juice and allowing the syrup to drain from it, it is placed in layers about one inch in thickness and ten inches in

breadth, under layers, equal in dimensions, of the herbaceous trunk of the plantain tree; the watery juices exuding from which filtrate through the sugar, and carry down with them all the dross which had been boiled up with it, leaving the pure sugar crystallized and white. It is then very light, and almost as porous as honeycomb. When dissolved, it leaves no sediment at bottom.* It is not always that this method is followed, and indeed the more usual process is to pour the sugar into vessels having the form of inverted cones, in which it granulates, and it is clayed in the same manner as in the West Indies.

Some considerable sugar plantations are established at Cuarnavaca, in the plains situated below and twenty-five leagues south of the City of Mexico, where the climate is favourable to the culture of the cane, the thermometer ranging between 70° and 90° Fahrenheit.

These plantations are laid out in a very complete manner and on a very extensive scale, comprising, generally, as many as 3000 acres. Irrigation is very carefully attended to by the Mexican sugar planters, who frequently convey water to their estates from a great distance, through costly aqueducts for this purpose, and for propelling their mills. Every cane field is surrounded by a canal, so that they are enabled at pleasure to admit the water to overflow its surface.

On a plantation containing 3000 acres, about one-half will be in pasture, provision grounds, and woodland, and of the other half which is brought into cane cultiva-

* Sir George Staunton's Account of Lord Macartney's Embassy to China.

tion, one-third will be fallow, a system of culture which is the more necessary, as little or no manure is used to the land. Nursery grounds, for providing cane plants, are very general.

The house of the proprietor is usually a splendid building, with piazzas and balconies, situated close to the works, which are on a corresponding scale, with gardens, orange and plantain groves, and surrounded by a village wherein the Indians employed on the plantation reside. These, on an estate of the extent mentioned, will amount, with their families, to about eleven hundred souls. Among the buildings considered necessary, a church is always to be found. The Indian labourers are paid from two to three reals per diem, (one shilling to one shilling and sixpence,) and, as the plantations are mostly at an inconvenient distance from any town, one necessary part of the establishment consists of a store from which the Indians can be supplied with dry provisions, clothing, and other articles of comfort and necessity. The Indians inhabiting this section of the republic have a mixture of negro blood, and are an intractable race.

Some part of the produce is consumed in the form of syrup, but the greater part is refined and made into loaves of one arroba (or twenty-five pounds) each; the quality is equal to English single refined sugar; it is very hard and compact. The produce of refined sugar on a property of 3000 acres will usually amount to 30,000 arrobas. The sugar produced in Mexico is all taken off for domestic consumption, and it is the custom for sugar planters to be also proprietors of stores in the City of Mexico, whither their produce of sugar and

rum is conveyed for sale, by the mode of transport universal in that country, on the backs of mules.

The more distant districts, situated on the Pacific, are supplied with sugar-candy from India.

The fine and fertile Island of Cuba produces sugar in great abundance. The quantity exported in the first ten years of the present century amounted, on an average, to 32,200 tons in the year, which quantity has since been materially augmented, and now nearly reaches half a million of boxes annually, each box containing about three and a half hundred weight. The sugar exported from Cuba is all clayed, and the largest portion now finds a market in the north of Europe.

In the United States of America much attention has lately been given to the growth of the sugar cane, and large quantities of sugar are made in the Floridas, Georgia, and Louisiana. In the latter of these states the produce is declared to have amounted in the year 1828, to 87,000 hogsheads. The system both of culture and manufacture is said to be similar to that followed in the West Indies.

We have already mentioned the Brazils as having furnished to the English Colonists their first lesson in the art of making sugar. From what we can learn, this art is now altogether in the hands of uneducated people in that country, and it is doubtful whether any improvements have been adopted by them, or if the principles which should govern the manufacturer in his operations are better understood by the Brazilians of the present day than they were by those from whom, nearly two centuries ago, the cane was procured by the English settlers in Barbadoes. The export trade of Brazil in sugar has

always been very considerable; and, as we have seen, the markets of Europe were at one time almost wholly supplied from that country. The sugar exported by them is all clayed, and like that from the Havana, is known under the three denominations of white, yellow, and brown, forming three divisions of the conical loaf after claying. The rum made in Brazil is said to be of execrable quality, and altogether unfit for exportation.

In a report made by Major Moody, which was printed by order of the House of Commons in February, 1826, there is a statement of the comparative number of days' labour required, in different countries, for the production of equal quantities of sugar, viz.

In Guiana	206	days.
Barbadoes	406	"
Tortola	653	"
Bengal	1200	"

The ample opportunities enjoyed by Major Moody for ascertaining these points, and his well known accuracy, would alone lead us at once to admit the correctness of his estimate; but some such fact appears wanting to account for the production of sugar being so small in India, with reference to the apparent capabilities of the country, where the wages paid to labourers do not exceed *twopence halfpenny per diem!*

CHAPTER XVIII.

ON THE ART OF REFINING SUGAR.

The art of refining sugar was first introduced into Europe by the Venetians, and was practised at Venice some time before it was adopted in any other European country. The foul and black sugar brought from Egypt at the end of the thirteenth century, was the first material upon which the art of the refiner was exercised. The Venetians, in their commencing attempts, converted this into sugar-candy, similar to that which came from India: but they soon sought to obtain the sugar by a quicker and more profitable process, and for this end they invented the form of the cone or loaf, the use of which obtained universally, and has continued to the present day.

The art of refining passed afterwards into every part of Europe where sugar was an article of commerce and consumption; and since America has been so fertile in the production of this commodity, refineries have consequently increased and extended over all Europe.

This art was first conducted by ignorance and chance; it continued without any material alteration for a very long period, and it is only of late years, comparatively, that science has assisted in the process, and has produced in it such great and marked improvements.

We have endeavoured to show on what principles the art of manufacturing sugar from the juice of the sugar cane should be founded; the process of refining should be considered merely as a sequel to the former operation, and should therefore be conducted on exactly the same principles. The saccharometer and thermometer are even more requisite in the refinery than in the boiling house, and every step of the process should be regulated by them. The water employed in dissolving the sugar previously to clarifying it, as will be hereafter described, should be united with it in fixed proportions; the most proper solution is indicated from 30° to 32° of Baumé's saccharometer. It is equally essential to regulate as much as possible the action of heat; charring and burning continue their baneful influence in every refinery where improved methods are not employed to prevent this very great evil.

The thermometer alone can indicate the term when evaporation ends and concentration commences, and can follow the various degrees of this concentration. The table given at page 149 will be found a sure guide by which these points may be ascertained. Fusion is the action of heat upon the water of crystallization; it begins at 279° Fahrenheit, when the concentration finishes. The thermometer serves also to follow its divers degrees, and to mark its last term, which takes place at 302° Fahrenheit. After this, heat acts upon the constituent prin-

ciples of sugar, which it decomposes, and the first degree of this decomposition is named caromel.

Lime has always been used in refining as well as in boiling sugar, and many causes have been assigned for its use. For a very long period the necessity for it was attributed to the presence of a greasy matter with which it was supposed the lime combined and separated it from the sugar. After Bergman discovered the oxalic acid, it was imagined that lime was required to neutralize this acid, which, it was supposed, existed in the molasses of the sugar. The fact is, that neither grease nor acid are united to the raw sugar, and the employment of lime in clarifying is hurtful in every respect. The various fluid and solid matters united with raw sugar, and from which it is required to be purified before it can be refined, have been pointed out. Let us now examine what is the action of lime upon these and upon the sugar itself. To the latter it certainly must be injurious, by combining with and tending to decompose it; upon the earthy matters it has no effect; it disengages extractive matter from the feculencies, and favours even their solution by heat. It is the great disadvantage of lime, that it renders matters soluble which are not sugar, and the presence of which necessarily opposes its purification. Lime is still farther injurious in opposing the coagulation of the albumen which is used in clarifying. It is not, therefore, in clarifying sugar that the use of lime is requisite; its aid is called for to surmount the difficulties which occur in concentration and crystallization, in consequence of the presence of molasses. When raw sugar is dissolved, the molasses with which it is tainted being more soluble, is dissolved the first, and

whatever may be afterwards done, nothing can remove it previous to the crystallization of the sugar. It is this molasses, upon which all the efforts of the refiner in clarifying are ineffectually bestowed; the lime combines with it, and rendering it much more fluid, it opposes fewer obstacles to the action of heat in concentration, and to the union of the saccharine particles in crystallizing; whence it may be clearly seen how important it is to remove, by a preliminary operation, the molasses which is found mixed with the raw sugar: then the assistance of lime might be discarded, and its injurious effects, which we have enumerated above, would no longer increase the difficulties of the intelligent refiner. Alkali could not, however, be wholly banished from the refinery, as it would always be found advantageous to employ it in making the sugar from the syrup arising from the scum, since it causes the sugar which remains united with the scum to be more readily extracted from it.*

Messrs. Boucherie, merchants, of Bourdeaux, some years ago awakened the attention of the French Government to the importance and necessity of improving the art of refining sugar. They proposed preparing it previously to refining it, and they received a recompense and encouragement from the Government in consequence.†

* Dutrone.

† Dutrone successfully applied, in a refinery, his method already described in manufacturing sugar. He observes, "In the month of August, 1783, Messrs. Boucherie and myself made the first application of these principles to the concentration and crystallization of the various syrups of their refinery; and experiment proved to us that a greater quantity of sugar could be extracted with much more certainty and advantage."

The sugar refined in France is, at the present time, very inferior in quality to that made in England; it is in general coarse, spongy, and of a bad colour and grain. Perhaps the reason Dutrone gives for the bad quality of the sugar, which he very much contemns and exposes, still continues to influence the French manufacturer. It still retains within its interstices a portion of molasses, and absorbs likewise a small portion of water, which, in adding to the weight of the sugar, enables it to be sold at a moderate price; it owes its sweet syrupy taste to the molasses, (a taste which predominates more than the saccharine taste with which the former is generally confounded;) this causes economy in the quantity of sugar consumed for the more ordinary domestic purposes. This sugar is, in consequence, in repute, and always can command a ready market, the coarse taste of many giving it a preference over sugar better purified.

A sugar refinery is generally built of brick or stone. It varies in its dimensions according to the number of pans used. A one-pan house should be about twenty-seven feet square, and should have six floors besides the ground floor. A house of two pans should be about thirty-six feet by forty-feet, and one of four pans about forty feet by sixty-five. The stove generally occupies one corner of the building; it is built of masonry; and its dimensions are from eight to fourteen feet square. The height of the ground floor, or fill house, should be nine feet below the girders; the first floor, called the warehouse, should be of the same height, and all the other floors above must be about six feet between the girders and the floor. There must be an aperture in each floor, and a brass pulley fixed on the highest story, in which a

rope works; this runs through the height of the building by the apertures of each floor, and serves to draw up the sugar to the respective stories. A sugar house cannot have too much light; damp and cold air must be carefully excluded.

The usual dimensions of sugar pans used in the London refineries are,

Top diameter..................	54 inches
Bottom diameter..............	44
Depth at side..................	18
Depth in middle...............	20
Standing curb..................	15

A pan of this size is capable of boiling from 33 to 35 cwt. of sugar.

The coolers are nearly of the same shape as the pans, rather more than a foot and a half deep; they are made of thin copper; their number is generally the same as the pans. The clarifying cistern is made either of copper or lead; it is a large receiver, placed as near as possible to the sides of the pans, and should hold at least one-third more than the contents of all the pans collectively. The syrup pipes are tubes of four inches diameter, made of thin copper or tin plates, and suspended perpendicularly over the clarifying cistern from the upper story through the whole building. The sugar, after being concentrated to the proper state, is conveyed from the pans to the coolers, and from the coolers to the moulds, in basins; these are vessels of from four to six gallons capacity. The scummers are about fourteen inches in diameter; they are pierced with holes like a colander. The ladles are of various sizes. The colanders, through which the clay is strained, are about

eighteen inches diameter, and about fourteen inches deep. There are smaller ones used for the purpose of straining the bullock's blood previously to its being employed in clarifying. The scum cistern is a wooden receiver, usually lined with lead ; it should be nearly as large as the clarifying cistern. A leaden ledge, called a bench, is put before the pans, rising in front; this prevents the sugar from being spilled and wasted. There is a pewter or leaden pipe communicating with the lime cistern and the pans, and there are other pipes to convey water to the pans and to the lime cistern, as it may be required. There should be a copper pump fixed to the clarifying cistern, as well as a spare pump of the same kind. There should be a large vat for lime water ; another for the purpose of soaking the moulds in water before they are used ; this is from four to five feet deep, and of such a capacity that all the moulds used in one day's refining may be placed in it at one time. There are clay cisterns for macerating and properly working the clay ; this is done by thick sticks of hard wood, whose lower ends are studded with iron points. The construction of the chimney and the setting the pans are of very difficult accomplishment; they require great skill and care. It is necessary in fixing the pans, that the fire-bricks and lumps which burn away under them three or four times a year, should be so arranged as to allow of their being taken out and replaced, without pulling down and deranging the whole work; while the chimneys must be so managed that a sufficient and proper degree of heat may be obtained for each story. Different sorts of sugar, and occasionally the same sort, require various degrees of heat. There

should accordingly be the means of regulating the heat in each floor. The heat is introduced through the pan chimney, the stove chimney, and sometimes through flues raised on purpose. It is communicated from the chimneys by shutting the register plates after the fires have been nearly extinguished, and the remaining ashes are perfectly clear. There are small iron doors communicating with the chimneys on every floor; after shutting the register plates, these are opened, and heat is conveyed where it is required.

The cockell is an iron trunk used to dry the sugar in the stove. The moulds and pots are made of clay, and are of various sizes. Many different kinds of wicker work baskets are employed in a refinery, refining baskets, scum baskets, &c.

The manner of refining sugar as usually practised in England, in houses where no recent improvements have been adopted, is thus conducted. Into each of the clarifying pans six quarts of bullock's blood, (called *spice,*) are put, to which a certain quantity of lime water is added; the pans are then filled to the brim with raw sugar; the proportion of lime water should be so regulated, that the solution of sugar may be in the most favourable condition for clarifying, which we have indicated above. In about two hours, with a moderate degree of heat, this mass may be expected to reach very nearly the boiling point, but it should by no means be allowed actually to boil. In this time the earthy particles and other extraneous matters will be separated from the sugar by the joint action of the heat and the *spice;* this latter seizes on all the solid matters both feculent and earthy, and raises them to the surface of the fluid

in the form of a thick brown scum; this must be gently removed with a broad scummer, and being put into a tub or bucket, is conveyed into the scum cistern. Previously to this, however, and about an hour after lighting the fire, two quarts more of *spice* are added to each pan. After the first scumming, another quart of *spice* is stirred into about two gallons of lime-water, and this mixture is poured into each pan. When the sugar is again brought to a degree of heat approaching to boiling, a second scum is thrown up, the albumen collecting in this second time the impurities which had escaped it at first; this scum is removed as before. The operation is reiterated a third and even a fourth time, with a smaller quantity of *spice*, till the syrup throws up a clean milky froth, and appears quite bright and transparent. Sometimes the syrup is subjected to a farther test by a close inspection in a bright metal spoon, when, if there be any remaining foulness, it is readily discovered. In preparing very fine sugar, it is usual to improve the natural colour by the addition of a small quantity of indigo; about six pennyweights troy, very finely powdered are filtered through a piece of woollen cloth into a basin of fresh water; this being well stirred is thrown into the pan just before the sugar is entirely cleared. The sugar being once scummed after this operation, the grosser particles of the colour are taken off in the last scum, and the remainder is incorporated with the sugar in the pan.

When the sugar is perfectly clarified it is *skipped off*, or passed into another vessel; for this purpose a wooden channel is laid, communicating from the pans to the clarifying cistern. Over this cistern an oblong basket,

about sixteen inches deep, is fixed upon large iron bars; a thick blanket is fastened to the basket, and through this blanket and basket the syrup filters from the channel into the cistern; a quantity of the drainings arising from former boilings is then added. The contents of the cistern is measured by a graduated rod, and a sixth or ninth part of the whole is pumped back into the pans. When this is done, the fire is made to give out a great heat, and the second operation, *evaporation*, now commences. The charge in the pans very speedily begins to boil; it must be continued in this state for some time, but not with too intense a fire. To prevent the sugar from boiling over, a small quantity of butter, about the size of a walnut, is cast into the boiling mass. The syrup will generally be sufficiently concentrated in from twelve to thirty minutes. Various signs indicate this state, the bubbles dragging heavily over the surface, the clammy liquid falling in ropes from the proof-stick, and principally by that test, which is especially called the *proof*. For this purpose the boiler draws the stick out of the boiling liquid with his right hand, and, placing his left thumb upon the sugar, draws it across the stick, carrying away on the end of his thumb as much of the sugar as will adhere to it; he then, by means of a candle placed in a black box, called the proof box, having three sides enclosed, thus emitting light only at one side, by repeated trials, drawing the sugar to a thread between his thumb and forefinger, and carefully examining it by the candle, determines when the concentration is complete. When this is decided, the fire is damped and nearly extinguished. The syrup is then conveyed, by means of basins, from the pans into coolers; care, how-

ever, must be taken that enough is left in each pan entirely to cover and preserve the bottom from being burnt. The pans are then again supplied with a fresh charge for the next concentration. The contents of the cooler are gently stirred to prevent a crust from forming on the surface, and two more *skippings* or boilings are added and mixed with the first in the cooler. That part of the process of refining called *granulating* is now pursued. For this purpose the sugar is agitated in the cooler by an instrument, which, from its resemblance to the oar of a boat, is called by the same name; the violent motion, continued for several minutes, seems to assist and favour the crystallization. Upon this operation much of the success of the process depends, for if the sugar has not been disturbed enough, the grain will be large and loose, and its colour not sufficiently white; but if, on the other hand, it be agitated too much, the grains will be broken, and the sugar disunited in its parts, and though close and smooth, it will be without lustre.

The fill house is on the ground floor of the sugar house. The moulds, in the form of inverted cones, are ranged in it, upright on their points, in rows, two or three deep, having been previously prepared by soaking and washing; each has a hole at its apex of an inch diameter; this is now closed up with a bung of wet linen rags. The number of moulds should be sufficient to contain the quantity of sugar in the coolers. They are propped up by other moulds, for which purpose those which are broken or injured are put in requisition, and placed with the broad end downwards, in front of the outward rank by way of an abutment; these are called

stayers. The skippings in the coolers being thoroughly mixed together by stirring, are laded out of the coolers in succession, and not all at once, into basins, conveniently situated; these are carried into the fill house, where the sugar is poured into each mould, at three different times, before it is quite filled to the brim.

The moulds being filled, the next operation, which is that of stirring the sugar in them, is called *hauling;* this is done in order that the little crystals already formed may spread equally through the whole extent of the fluid, and serve as a support and attraction to the saccharine particles as the heat abandons them, thus establishing a nucleus for the aggregate and crystalline mass which is formed by the sugar in passing to the solid state. For this purpose a knife, made of hard wood, and of a size proportionate to the mould, is used; with this tool, keeping the hand over the centre of the mould, the sugar is scraped from the sides by successive strokes downwards, carried all round; when two revolutions are performed, the sugar is left some minutes at rest till it has acquired some firmness; the operation is then performed again, and once or twice afterwards, according to the discretion of the boiler.

The process just described relates to sugar once refined, called single loaves; double loaves are usually cleared with the whites of eggs instead of *spice,* (two hundred of which are necessary to each pan,) and with fresh water instead of lime water. With respect to the proof, one rule only can be laid down, viz. that the sugar must be boiled higher as the moulds which are to contain it increase in size. When the sugar is cool and fit for removal without damage, the moulds are pulled up

into that floor of the house which is best suited for receiving them, and where a proper number of well-sorted pots are placed in ranks for this purpose; the bung of rag is taken out, and the sugar is pricked at the point with an awl; the moulds are then set upon the pots. In twenty-four hours after the loaves have been placed on the pots, the quantity of syrup which will have drained from the sugar will very nearly half fill the pot on which the mould stands. One or two loaves of each filling are taken out that the state of the loaves may be examined. In order to remedy the inconvenience which attends this turning out of the loaves for examination, moulds made of flint glass have lately been introduced; one or two of these are used at each filling, and the sugar in them being treated in the same way as that in the earthen moulds, affords a ready means of ascertaining, at all times, the progress of the whole filling, and avoids the necessity of disturbing the loaves before they are neat. If the syrups are not sufficiently drained they are left unclayed for two or three days longer, and the warmth of the room in which they stand is somewhat increased; but if they appear in a fit state, they are prepared for receiving the first clay, which is laid on either the next or the third day. The new made loaves are judged to bear a healthy and promising appearance when the syrups have quitted the broad part of the loaf and are evenly drawn together; when the whole surface is compact and smooth they are fit to receive clay.

When the syrup has scarcely drained from the base of the cone, when the apex or narrow and moist end is not evenly drawn off to a line, it may be concluded that

the sugar is over-boiled, or of an ill quality; time must be given and the heat increased to place it in a fit state for claying. On the other hand, if the moisture is shrunk and settled, and of a pale colour just round the apex of the cone, there is reason to apprehend that the sugar is under-boiled, or too free, in which case the surface will appear loose and want that smoothness which the well-boiled loaves exhibit. When this is the case it must be slightly clayed, and care must be taken that the clay be not too thin or wet. Before the operation of claying, the thin crust which had been formed round the edge of the mould by the motion of the knife, is scraped from each loaf into the receiving box; the base of the loaf is then pressed by that part of the hand which is nearest to the wrist; this serves not only to make a small concavity for receiving the first clay, but also gives a proper solidity to the bed on which it is intended to rest. Previously to claying, the first or green syrup is taken away, and poured into large earthen vessels called gathering pots, and the moulds are again placed on the emptied pots. Then a small ladleful of wet clay is poured on the face of each loaf. This first clay becomes quite dry in five or six days, it forms a cake, which is taken off, and laid by for future use. On removing the clay it will be found that the whole surface of the loaf has shrunk under it, and has, in consequence, become concave.

With an instrument called a bottoming trowel the sugar which adheres to the side of the mould is cut away, and a small quantity of scrapings, or of lumps broken down for the purpose, is added to the loose sugar which the trowel had cut; this is pressed down

on the surface till it becomes properly levelled, and is brought to a suitable degree of firmness for bearing the next clay.

On the following day the loaves are clayed a second time; when this clay is dry it is removed, and then each loaf is drawn out of its mould and carefully examined. This part of the process is called overseeing. The fine sugar is sometimes found after the second claying to be what is called neat, that is, there will be no appearance of any molasses remaining in the loaf, and although the head may be still moist, it will be perfectly free from all discolouration. The heads of one or two loaves are cut off with a trowel, that the state of the sugar may be perfectly ascertained. If this examination be satisfactory, the claying is now complete, and it only remains to scrape off all the irregularities and impurities occasioned by the contact with the clay; this is done with an iron instrument called a brushing hook, and with this a number or letter is scratched on the loaf. To those loaves which are not found yet entirely free from molasses, a third clay is given; this is laid on in a thinner mass than the former.

The loaves being neat and brushed off, they must still continue some days in the moulds to acquire face, or that hardness of surface which will enable them to stand firm on their base when they are turned out of the moulds. During this time they are once or twice loosened in the moulds by a gentle blow against a post; this not only prevents adhesion to the moulds, but facilitates the precipitation of the remaining moisture. During this time the points must be examined, as they sometimes are disposed to deliquesce. When this is

found to be the case, the moulds are taken from the pots, and the loaves are placed on their bases with the moulds still upon them, the floor on which they are to be placed being previously covered with clean brown paper. This situation must be either on the stove head or in some warm place, for if they be exposed, uncovered, to the action of the cold air, the moisture remaining in the head will not descend into the body of the loaf, and be equally dispersed.

With this treatment the moisture is generally dissipated in about twenty-four hours. If, however, no such precaution had been taken, the loaf would have been disfigured and spoiled, as the syrup would have settled in the head and discoloured it. The loaves, as they are taken off the floor, are carefully examined and cleared of any specks with a small knife; they are then set in the stoves, the finer loaves being first papered. If any should still remain with discolouration at the points, these are cut off: the loaves thus treated are called *spot loaves.* After being in the stove from five to seven days, the sugar is entirely dry and fit for sale and use. The management of the sugar after boiling is nearly the same whether it be fine or coarse: the latter requires more clay than the former. Large lumps are frequently obliged to be clayed four times, and it is a general rule to apply a greater degree of heat to bring the sugar forward, in proportion to the inferiority of its quality. The increased size of the moulds likewise depends upon this. The double loaves are generally from 12 to 13 lbs. weight; the powder or Hamburgh loaves, from 13 to 14; the single loaves about the same weight; titlers about 27 lbs. the Prussian 28 to 35 lbs.; large lumps as much as 50 lbs.

The coarse sugar takes much longer time before it is fit for use than the finer sort, in consequence of the greater size of the moulds in which it is made, and of the greater viscidity of the syrup which is to be drained from it. The manufacture of the single loaf is generally completed in twenty-six days, while the larger require about thirty-six to forty-two days. These periods have of late years been very much abridged, by substituting for the clay a saturated solution of refined sugar, to be poured upon the base of the loaf. When this plan is adopted, all kinds of sugar are ready for the market in three weeks from their boiling. It is proper to make the solution for this purpose from sugar of better, or at least as good quality as that under process.

It is customary to begin the first day's refining with the finest sugar intended to be made, and to proceed daily with sugar of a lower quality. The reason of this is, that the most advantageous disposition of the syrup and scum may be obtained. The order is generally, the first day, double loaves; the second day, Hamburgh or powder loaves; the third day, titlers; the fourth day, Prussian lumps; the fifth day, large lumps; and the sixth day, *bastard boiling:* and this period constitutes a complete series of refining, denominated a complement. In some refineries, where double loaves are not made, only five days are taken to complete the series, giving one day to each kind; and, on the contrary, other refiners occupy as many as seven, ten, and even twelve days in completing a complement.

The double loaf is sugar refined twice. In the first process, lumps called *melters* are made; these are low boiled, and should be but little stirred, that the strength

of the sugar may be preserved unimpaired. From these again refined, the double loaf is obtained. A very moderate heat is required to make the finer description of sugar *neat*. The middling qualities require warmth, and the coarsest lumps and *bastards* thrive in a glowing heat. In proportion as sugar is more highly boiled, it will bear and require more heat; for the syrup which is to drain from it being more viscid as it is more boiled, must be kept in a fluid state by heat, to enable it to separate itself from the sugar. It is not necessary that lumps should be made quite *neat;* it is the constant practice to cut of the wet head as far as there is any discoloration: these wet tips, called *lump headings*, are put into a large mould, and again suffered to drain; when dry they are either used in making double and powder loaves, or they are bruised and mixed with brushings to put on the base of the loaves, previously to claying.

The syrups which drain from the moulds are so considerable as to exceed the sugar in quantity, and are therefore of great importance in the refinery; upon the proper management of them much of its success depends. When the loaves are prepared to receive the first clay, the syrup is collected into vessels called gathering pots, each of which contains from fifty to sixty pounds of syrup; there are about fifteen of these obtained from each pan of sugar or goods. This first draining is called *green syrup*, on account of the new or green state of the sugar from which it runs. When the second clay is removed, the syrup is again collected, this is called the *second runnings*, it generally averages about eight gathering pots *per* pan. After the moulds are finally removed

from the pots, the third and last collection is made, this is called *drippings*, and is about five gathering pots *per* pan. Sometimes the syrups are collected oftener; those syrups which drain from the sugar the last are much finer and more valuable than those which first flow from it. Making necessary allowances for particular circumstances, the syrups may be appropriated in nearly the following manner. Green syrups of every kind may be either mixed with raw sugar, or applied to the making of goods two degrees in quality lower than those from which these syrups were produced. Second runnings of every kind may be incorporated with goods one degree below those from which they were produced. Drippings may be added to raw sugar and other proper materials, in making the same kind of goods as those from which they have been obtained.

The finer syrups are conveyed through the syrup pipes into the clarifying cistern at the same time in which the sugar is first skipped from the pans. The syrup pipe discharges its contents into the clarifying basket, so that it passes through the blanket, and then it is pumped from the cistern into the pans.

The quantity of syrup that is allowed to each pan may be estimated thus; for double loaves six gathering pots *per* pan; for powder loaves ten do.; for fine single loaves fifteen do.; for middling loaves twenty do.; for brown single loaves and Canary lumps twenty-five do.; for lumps thirty or forty do.

The green syrup arising from the coarsest lumps is boiled by itself, and after sufficient evaporation, is poured into large moulds; this is called *bastard* sugar. The second running of the coarsest lumps assists in making

pieces; these are a better kind of *bastards,* which are either boiled from syrups that are too good to make *bastards,* or are made of such syrups and a small portion of cheap and bad sugar which is too poor to make lumps. In the latter case they are called *sugar-pieces;* all the syrup which comes from these is boiled again either to make *bastards* or other pieces, according to its goodness. But no attempts are made to obtain any sugar from the syrup which flows from the *bastards;* this is at once put into casks, and sold under the name of molasses. Every care is therefore taken to keep as much weight of sugar as possible in the *bastards.* For this purpose they are boiled as highly as can be ventured, without incurring the risk of making *stopped bastards,* or *bastards* from which the molasses will not run, as this effect is produced by over-boiling as well as by the ill quality of the materials. The concentration of bastards and pieces is a most difficult operation; the materials from which they are made contain but a small comparative portion of crystalline particles, and, perhaps, much of the mass may be formed by the concretion of the molasses which was originally united to the raw sugar, and by that part of the sugar which is decomposed and rendered uncrystallizable by the frequent boilings to which the various syrups have been subjected before they reach their final destination and are boiled for *bastards.* These inferior productions are merely stirred, while hot, round the coolers very gently with an iron scraper, just sufficiently to incorporate the grain with the whole mass, and assist in producing the necessary granulation. The oar is not used to agitate them in the coolers, nor are they hauled in the moulds. The stopper is not taken

out of the moulds of these goods until five, six, seven, or even eight days after the syrup has been put in them. The sugar of this description wants time to harden, as here the concretion of the dense fluid must be depended on to make the goods; this forms at the lower part of the mould into small stony substances of the nature of candy; when the stoppers are withdrawn, these remain near the point of the mould, and are what is called *bastard grain*. *Pieces* and *bastards* are seldom clayed more than twice; they are knocked out of the moulds as soon as they are considered dry enough; the wet heads are cut off and put into a large mould, these are called *bastard heading* or *smear;* the grain usually forms a stratum not more than two inches broad, beginning about four inches from the point of the mould; the *bastards* and *pieces* are then put into the stoves in moulds; from five to seven days will suffice to dry them, as they are not rendered, like lumps and loaves, perfectly free from moisture. They are then taken out and conveyed to a place adjacent to the mill, in which they are all ground together, or sometimes they are divided into three parts which are ground separately, and sold at different prices.

The stoving of bastard lumps is now very frequently dispensed with, and so soon as they have delivered all the molasses which the claying causes to drain from the moulds, the sugar is turned out, in which state it is easily broken down without the aid of the mill.

The English refiner does not willingly allow a particle of sugar to be wasted in his process. The scumming from the pans is not thrown aside till every particle of sugar which he can obtain from it is ex-

tracted. The scum of double refined sugar is often put into the pans again and mixed with raw sugar for the production of inferior goods. But in general it is boiled by itself the same day it has been taken off, after the boiling of the sugar is finished. Three quarts of spice are put into the pan, and a quantity of lime-water is added until the pan be four-fifths full without the pan-brace; about three hundred weight of the scum is then stirred into it; a moderate fire is made, and the scum soon separates from the fluid and floats upon the top; the bottoms of the pans are constantly scraped to prevent any foulness from adhering to and charring them; the fire is suffered gradually to increase till the liquid is on the verge of boiling, and the scum is slightly broken. It is kept simmering thus for several hours; the cooler which is destined to receive it has a strong wooden frame attached to the top of it, and upon this a basket is placed to which a coarse bag is fitted. The contents of the pan are poured into the basket and bag, and then the mouth of the bag being drawn up and well twisted together, a strong board is laid upon the bag with several weights on the board to press down the scum. In the space of an hour or an hour and a half the bag should be again twisted and pressed; the liquor which oozes abundantly through the bags is generally put into the pans the next morning; its thinness renders it useful in clearing the pans, and if any gross matter should have passed through the bag, it is drawn off with the rest of the scum of the sugar when cleared.

The scum, as taken from the pans is called *fat scum*, and the liquid matter obtained from it bears the same appellation; this is to distinguish it from the poor meagre

liquor which is expressed from the same scum by a second process similar to the first operation. This liquor is commonly used in bastard boiling or in the coarsest lumps. A large proportion of the first scum is always left from every refining, and used in bastard boiling. The first, or grossest scum, is set aside for this purpose, and kept separate from the finer and later scums, which are daily boiled as above described. The liquor thus obtained from the fat scums being full of sugar, is found very useful in promoting the strength and adhesion of the bastards.

After the scum is thus pressed and drained, the exhausted remains, called rubbish-scum, are sometimes, at length, consigned to the cockell to be burnt for fuel, but are most generally sold and submitted to a still farther ordeal; and when it is now reduced to such a state that it appears to be a mere earth resembling garden mould, it is yet thought of sufficient importance to create a distinct business; and scum-boiling is a process carried on entirely as a separate vocation. In the state above described the scum is again tried over the fire by the scum-boiler, who contrives to extract from it a small quantity of saccharine matter.

The proportion of refined sugar, which is said to be generally obtained from one hundred weight of raw sugar is 61 lbs., bastards 18 lbs., molasses 28 lbs., waste 5 lbs., total 112 lbs.

But this proportion of course varies according to the quality of the sugar, and the skill employed in refining it.

The best extract yet obtained by the most experienced refiners is stated to be in 112 lbs., refined 68 lbs.,

bastards 19 lbs., molasses 21 lbs., waste 4 lbs., total 112 lbs.

The method we have just described is the one usually employed; but within the last twenty-five years there have been many improvements in this art, some of which are found very much to facilitate the process, to increase the produce, and to improve its quality.

CHAPTER XIX.

ON PATENTS FOR IMPROVEMENTS IN REFINING SUGAR.

In 1801, a patent was taken out by Mr. Wakefield, for a method of expressing molasses from sugar previously to refining; we cannot find that it has ever been adopted.

In 1805, two patents for refining sugar were granted, but they do not appear to have been any material improvements.

In 1809 and 1810, two more were obtained, but they have not been of sufficient consequence for it to be at present known in what these inventions consisted. In the beginning of 1812, M. Constant took out a patent for refining sugar. His invention consisted in using vegetable charcoal in the proportion of five to ten pounds per cwt. of raw sugar, for the purpose of clarifying. The difficulty of afterwards effectually separating the charcoal from the sugar has been stated as an objection to this plan.

It was in this and the following year, (1812 and 1813,) that the celebrated patents of the Honourable Edward Charles Howard were granted, although it was not for

some time after this period, and through the unwearied exertions of Mr. Hodgson, that these improvements were introduced.

In exposing the sugar pans unprotected to the action of fire, charring and decomposition of some portion of the sugar must inevitably take place, and it may, perhaps, be fairly estimated that two-thirds of the uncrystallizable syrup which drains from the sugar is produced by the high heat used in the concentration of the syrup. Howard's patent was the first which sought to provide against this evil, and so great were the advantages which resulted from the adoption of his plan, that when, at length, it became known, notwithstanding the very great expense attendant on its erection and use, it was so much esteemed and employed, as to produce to its proprietors a most ample reward.

Mr. Howard's first patent related more particularly to the method of preparing and fining the sugar; the second to the manner of applying and regulating heat. The sugar refined by this process is submitted to an operation preparatory to boiling. Raw sugar is mixed with such a quantity of water as to form a magma of the consistency of well-worked mortar; after being left at rest for the space of an hour or more, it is heated to a temperature of 190° to 200° Fahrenheit; the improved manner of applying the heat will be described hereafter; a thinner magma of sugar is added, and the whole is then put into moulds; when it becomes cold these are unstopped, and the molasses suffered to drain from them. When the draining is completed the upper portion of the mass of sugar is pared down to an uniform surface: the sugar so pared off is mixed with cold

water till the magma acquires such a consistency as will not readily allow of its closing behind the stirrer; in which condition it is replaced on the firm even surface before prepared; as soon as the magma becomes moderately dry, a saturated solution of fine sugar in cold water is, with the intervention of a float, or similar guard, poured upon it, about half an inch deep; or the magma may be taken off, re-wetted, and replaced on this surface; one or other of these operations is to be repeated as often as the nature of the sugar may require. When this proves open-grained, the finer the sugar is ground which is made into the magma the better, because the moisture is thereby prevented from descending too fast or unequally into the loaf.

The loaves are examined from time to time, and the proper period for terminating the operation is ascertained by observing the greater or less freedom with which the moisture is admitted, and by the colour of the molasses dripping out. The temperature of the place in which this process is conducted should be about 60°, and raised to 80° or 90° after the surface of the loaf becomes dry for the last time. It is necessary to perforate the surface when it is become so solid or iced over, as to prevent the access or escape of air into or out of the sugar, as otherwise the free percolation of the molasses would be impeded.

This primary operation being completed, the neat sugar is divided in the usual manner from that which retains the molasses; the former is then refined by pouring upon it six lbs. of boiling water to every five lbs. of sugar, deducting about six per cent. for the moisture previously contained in it. The sugar is dissolved by

stirring, and the impurities are allowed to subside: the solution is then drawn off from the impurities, and to complete its clarification, finings are now added. These finings are prepared by slaking well-burnt lime with boiling water, so as to obtain a cream of lime; to this is added an equal bulk of water, and the mixture is boiled for some minutes until the lime assumes the appearance of fine curd; the extraneous matter is washed away, and the lime and liquor are run through a fine sieve. The next part of the process is to dissolve, in about twenty-four times its weight of water, about 2½ lbs. of alum for every cwt. of solid sugar that is to be refined, adding to such solution about 3 oz. of whiting for each 2½ lbs. of alum; the mixture is stirred till effervescence ceases. It is then allowed to subside, and the solution is drawn off from the precipitated matters; after this it is put with the prepared lime curds, shaken up with the water they retain, the whole being agitated during the effusion; the curds are to be in such a proportion that paper, stained with turmeric, shall barely change its colour by immersion in the mixture, and shall recover its former yellowness when dry. The finings, thus duly prepared, are suffered to settle to the bottom of the containing vessel, and after draining off the supernatant liquor, the finings are placed upon blankets supported in the manner of a filter, and the moisture is drained off until the mass begins to contract, and cracks on its surface; the finings are then fit for the clarification of the sugar; add the solution of sugar to them in such a proportion as will bring it to a creamy state, and then pour the whole, and mix it equally into the sugar to be fined. The clarified sugar is suffered to remain for several

hours before the bright liquor is drawn off from the finings. The evaporation is then commenced.

Mr. Howard, in the specification of his second patent, which was dated on the 20th November, 1813, recommends that the refining of the sugar shall be effected by placing it, mixed with a proper proportion of the finings, in a vessel having a perforated bottom, through the small holes of which steam is allowed to enter, until the sugar is fully dissolved and heated to the temperature of 200 degrees of Fahrenheit's scale. He then proceeds, either by filtration or subsidence, to remove the impurities from the sugar. If by filtration, the solution is made to pass through Russia duck cloth, and, in order to assist the operation, the heat should be kept as near as possible to the degree above-named. If the impurities are separated by subsidence, the solution must be farther diluted, until its specific gravity is not more than one-fifth greater than that of water. But the most important part of Mr. Howard's invention consists in his availing himself of the fact that fluids will boil at much lower temperatures when relieved from the pressure of the atmosphere, than when under the ordinary atmospheric pressure. He directed the syrup to be placed in a close vessel so formed as to allow the access of steam to its exterior surface, for the purpose of heating its contents; and employed an air pump, with a condenser for steam by injection, as used in steam-engines, for making and keeping up a vacuum in the concentrating vessel, so perfect as to support not more than one inch of mercury.

As the employment of vessels, thus constructed, of course renders impracticable the usual method of examining the progress of concentration in the syrup, Mr.

Howard furnished a scale of pressures by the mercurial gauge, and of corresponding temperatures, whereby to regulate the process, and he likewise described an instrument, by means of which a sample of the goods may at any time be taken without admitting air into the pan. This instrument, or proof stick, is a tube inserted in an inclined position through the side of the pan fitting air tight at the juncture: the outer end of the tube is open, the inner end closed, but an aperture is made low enough to be immersed in the saccharine solution; concentric with this tube is inserted another short tube, which is capable of being moved, by rotation, one half turn, and has an aperture corresponding to that in the fixed tube. A plug is then constructed so as to lay hold of this inner tube, and to turn it that its aperture may be made to coincide, or otherwise, with the aperture in the fixed tube; this plug has a cell or chamber so situated, that when inserted for the purpose of examining the solution, it will be filled through the apertures in the tubes, when, the inner tube being turned round, the apertures will no longer coincide, and the plug, with the syrup it contains, may be withdrawn without allowing the external air to communicate with the contents of the vacuum pan.

When the sugar is sufficiently concentrated, Mr. Howard directs it to be withdrawn into a granulating vessel, whose office is similar to that performed by the usual cooler; this granulating vessel is, by means of steam applied to its external surface, heated to a temperature of 150° to 180° Fahrenheit, and the usual stirring is given to effect granulation, raising the heat to 200° before filling the moulds.

By this elegant method of concentrating saccharine solutions, all danger of overheating is clearly avoided, and, as a consequence, the sugar presents a boldness and brilliancy of crystal, which had never been attained by any previously known method.

In 1815, a patent was granted to Messrs. Martineau, for a new method of clarifying vegetable substances. The articles employed by the patentees for clarifying sugar, are, 1st, animal charcoal; 2d, bituminous earths; 3d, certain argillaceous earths; and 4th, the vegetable charcoal usually called lamp black. The first mentioned articles, however, are preferred in the process of refining and clarifying sugar, rendering the sugar much whiter than when clarified by the common method. These substances are applied to clarifying in the following manner. The sugar pans are filled with sugar and water, or lime-water, as in the common method. To this sugar and water in the pans the above-mentioned substances are added in proportions, varying with the quality of the sugar to be refined, from two to five pounds of charcoal for every hundred weight of sugar. Rather more than the usual proportion of the finings of eggs, blood, or other albuminous matter is added, in order the better to coagulate and combine the charcoal with the dirt contained in the sugar. The liquor is then well agitated in the pans, that the charcoal may produce a greater effect in blanching it; and after the coagulated albumen has completely risen in the form of scum, by the application of heat in the usual way, it is either removed as in the common process, or the whole of the liquid sugar and scum is poured upon the filters at once.

This method is found to whiten and purify the sugar,

but it is said that more than the usual waste attends its employment. It is adopted in several refineries.

In the same year Mr. John Taylor obtained a patent for a method of purifying sugar. This invention consists in separating the molasses and other soluble impurities from the raw sugar by mechanical means, without the intervention of heat. These impurities being abstracted from the raw sugar, the great injury caused by their presence in the process of concentration and crystallization is avoided. For this purpose the raw sugar must first be brought to a moist state, either with cold water or lime-water; no exact rule can be laid down for the degree of moisture to be given, it depending very much on the quality of the sugar, but in general the proportion of water may be from one-eighth to one-tenth of the weight of the sugar. The sugar and water must be well mixed, in any suitable vessel, and the whole then subjected to a pressure carried to such a degree as to express all the fluid part therefrom; this will be found to contain the molasses and soluble impurities, together with a certain portion of sugar in solution; and if the pressure be sufficient, the sugar will be rendered dry, and much improved in colour and appearance; the manner of applying this pressure is thus conducted. The sugar is inclosed in strong linen or woollen cloths, each of which is about thirty inches square, and being laid over a wooden box twelve inches square and two inches deep, some of the moistened sugar may be pressed in and the cloth folded round it, so as to form a square cake. A press is constructed with a platform capable of containing at least four piles of these cakes, which may be arranged so as to stand at a certain height, and may

then receive a degree of pressure which will cause the fluid part to flow out; this is to be received in a copper pan fixed upon the platform of the press, and furnished with a spout to convey the expressed syrup into a receiving vessel. While these cakes are being pressed, another set is to be got ready, and the first having been hardened by pressure, may be adjusted so as to keep the piles upright, and the fresh cakes being set upon them, may then be exposed to pressure. In this way a considerable quantity of sugar may be got into a press, and after having been moderately hardened, the whole should be taken down and again set up and exposed to a higher degree of pressure, which will render the whole dry and of uniform good colour and appearance. Bramah's hydrostatic press is found the most convenient machine for this purpose.

The sugar thus prepared and purified, can be refined into loaves with less expense and trouble, and in less time than is required for raw sugar not so purified.

The sugar contained in the expressed syrup may be extracted therefrom by the usual process of evaporation, and from its not being previously injured or decomposed by the undue application of heat, is capable of being wrought into an inferior sort of refined sugar.

This invention appears so simple in its application, and so beneficial in its effects, that we should have supposed it only required to be known, in order to be universally and eagerly adopted: but we cannot find that it has obtained very general use. We know, however, that the process has long been and still is pursued in an establishment, conducted by one of the most scientific refiners in London. We believe it is considered waste-

ful, by reason of some of the sugar adhering to the cloths, and of a farther portion being pressed out with the molasses; but the refiner, who knows so well how to extract every particle of saccharine matter from the gross scum, might, one would suppose, with comparatively little trouble, successfully extract the sugar absorbed in this preliminary process.

The more general adoption in the Colonies of Mr. Innes's method of separating the molasses from sugar would, of course, remove the necessity for this operation in Europe; and as it would appear that the impurities can be more readily separated when the sugar is recently made, and before those impurities have acted injuriously upon the crystals, it seems desirable, on every account, that the separation should be effected previous to its importation.

In 1816, Mr. Druke obtained a patent for a method of expelling the molasses from refined sugar; this method consists in using a magma of plaster of Paris instead of wet clay. There does not seem to be any advantage attending this; we cannot find that it has been any where adopted.

In 1817, a patent was granted to Mr. Daniel Wilson for certain improvements in boiling sugar. The object of this invention was to preserve the sugar from being charred through the exposure of the pans to the naked fire, from which they were wholly withdrawn, and their contents heated by an injection of boiling oil, through tubes coiled in the pans. This oil, which was heated in a separate boiler, and impelled through the tubes by the action of a forcing pump, returned again to the boiler, after communicating heat to the sugar, to be re-

heated and injected as before; thus establishing a constant circulation through the tubes.

This plan was pursued in one very considerable refinery some years back, and upon the destruction by fire of the building, was the occasion of litigation with the Insurance Offices. It did not appear, upon investigation, that the accident was occasioned by Mr. Wilson's apparatus, and it must be attributed to other causes that the invention has not been farther adopted. However ingenious it may appear, this process involves some serious and fatal objections. There is great difficulty, if not impossibility, in regulating the degree of heat. Oil will indicate a temperature which is highly injurious to and decomposes sugar; it likewise itself changes its nature, and becomes more viscid by frequent or long-continued heating, and will then take a still higher degree of heat, and work still greater mischief. No medium can be beneficially applied to the heating of sugar which is not unvarying in its temperature, or which can, by any possibility, impart to the subject acted upon, a degree of heat which would be injurious to it.

In 1820, Mr. M. Rohde patented a new method of separating and extracting the molasses or syrup from muscovado or other sugar. In this invention the crystals are broken, and the sugar is spread on linen or other absorbent cloths. These are then folded, and friction is used, by agitation or otherwise, to wipe off the molasses; this is absorbed in the cloths, and, together with the sugar adhering to them, can be again obtained by washing the cloths. We do not find that this plan has ever been pursued; it comprises all the objections which are raised against the hydrostatic press without any of its great advantages.

In 1825, Mr. Freund obtained a patent for a new method of clarifying sugar. This consists in employing pearl or potashes, and a light-coloured species of fuller's earth as a substitute for blood, the use of which latter is certainly unpleasant and objectionable, it having been ascertained by well-conducted experiments, that notwithstanding the utmost carefulness has been used in scumming and filtering, a portion of the blood remains chemically united with the sugar.

Mr. Freund recommends that fifteen pounds of American potash should be dissolved in 85 gallons of water, into this 2000 lbs. of raw sugar should be well stirred, and then allowed to rest for about three hours; from 20 to 30 lbs. of fuller's earth mixed with water to the consistence of cream is then added to the sugar in the pan. Thus prepared, 70 more gallons of water are added, and the fire is then lighted. We have not had any means for ascertaining the efficacy of this plan, which, if it has ever been used, is now entirely abandoned.

In 1828, Mr. John Davis patented a method of boiling sugar at low temperatures, by means of a torricellian vacuum, which he obtained by connecting his sugar pans with the upper part of a condenser situated upwards of thirty-three feet above the level of the place where the water from it was discharged; and as the pressure of the atmosphere does not sustain a column of water exceeding that elevation, the apparatus being first filled with water, which was permitted to escape at the lower extremity, a perfect vacuum would be obtained in the upper part of the apparatus, provided it were made completely air tight. But finding this great height

very inconvenient in numerous instances, he devised and has patented the following method of obtaining a vacuum by the condensation of steam from the boiling vessels. Near the sugar pan, which is a close vessel, is placed the condenser; this is a vessel of considerable capacity, constructed with double sides, with a small space between them to be kept full of water; and near to the condenser, but somewhat above its level, is placed another vessel, also made air tight. This second vessel is filled with water, the air being permitted to escape at the top, which is then closed by a stop-cock. A revolving agitator, formed of several perforated vanes, is placed in the interior of this vessel, the use of which is to free the water entirely from air, which is permitted to escape through the stop-cock as often as any is separated from the water. A pipe connects the top of the sugar pan with the condenser, the lower part of which is also connected by another pipe, with the upper part of the water vessel just described. Now, when steam is generated in the boiler, it fills the condenser, and then a small portion of it is permitted to pass on to the water vessel, and forces a sufficient quantity of the water into the condenser to convert all the steam, with which it is filled, into water, and thus a vacuum is obtained, which will continue till all the water is transferred from the water vessel to the condenser; and the capacity of these vessels must be such that the change shall not be completed till the operation of boiling the sugar, with which the pan was supplied is finished. The various connecting pipes are furnished with stop-cocks to cut off the connexion, as occasion may require; and both the condenser and water vessel are furnished with glass gauges connected

with them at top and bottom, showing at any time, the quantity of water they severally contain.

In the same year, (1828,) Mr. Cleland took out a patent for improvements in refining sugar, which wholly apply to the evaporation and concentration of the syrup. The principle of the invention consists in continually exposing a thin film of the liquid to the joint action of heat and air, and by that means effecting a rapid evaporation. The apparatus consists of a convoluted worm of great length, into which steam is introduced; this is made to revolve horizontally on its axis, partly immersed in the liquid under evaporation, which is thereby constantly taken up by it in the thinnest possible stratum, and being in contact with the hot surface of the metal, the aqueous portion of the matter is quickly formed into steam, and carried off by the surrounding air. The apparatus is thus contrived. A boiler, in which the steam is generated, has a shallow vessel, in which the syrup is put to be concentrated, so placed over it as to form the top or cover to it; over this a worm, supported by stays, is so placed that a small part of it only is immersed in the fluid; this revolves on an axis, which has a cavity at each end communicating with the worm. One end is supported in a stuffing box upon a hollow arm, which communicates with the boiler; this part of the axis which turns in the stuffing box is pierced with a number of small holes; the other end is supported by a solid arm, and is open at the extremity for the emission of the steam after it has passed through the numerous coils of the worm. The axis may be turned by a winch, or by a band passing on a pully it may receive its motion from any convenient prime mover. By this arrange-

ment the steam in the boiler acts upon the bottom of the evaporating pan, and raises the temperature of its contents, while at the same time, the steam passes by the arm through the small apertures in the axis into the worm, and, traversing all its windings, escapes finally at the opposite end of the axis into the atmosphere, after having parted with a portion of its caloric to the subject under evaporation. By turning the winch, every portion of the worm becomes covered with the liquid, and lying in contact with an extensive heated surface, vapour is given off, which is quickly absorbed by the surrounding atmosphere. Mr. Cleland's invention was used for some time in an extensive sugar house in London, and was found to possess some advantages; but its use has lately been abandoned for the apparatus of Mr. Kneller, a description of which will be found in the fourteenth Chapter. Mr. Kneller's plan appears to be very beneficial in rapidly evaporating syrups at temperatures equally low with those employed in Mr. Howard's celebrated vacuum pans; the sugar refined by its means, showing the same boldness and brilliancy of crystal which has for so long a time given a decided preference in the home market to sugar refined in vacuo.

The invention of Mr. J. T. Beale and Mr. G. R. Porter, which has been also described in the fourteenth Chapter, is successfully used in concentrating various delicate vegetable substances; operations quite analogous to that of the refining of sugar, to which process it is, therefore, doubtless, equally applicable, as well as to the original manufacture of sugar from the cane. The numerous contrivances which we have here slightly explained, fully prove how injurious the direct action of

fire upon the syrup under concentration is found by the refiner, and how anxious he is to devise some plan by which these prejudicial effects may be obviated. This method of applying heat seems to offer every means required for completely and successfully securing the object proposed to be attained, with simplicity, economy, and safety.

In times like the present, when the accumulation of capital and general competition have reduced the rate of profits to a scale so comparatively moderate, it is matter of necessity for every manufacturer to keep pace with, and if possible to be somewhat in advance of the general progress, producing his articles with greater celerity or economy, and excelling his competitors in the quality of his goods. During the time that Great Britain was the principal, if not the sole manufacturer, for all Europe, it might suffice to continue in the beaten track; but this will no longer answer. The descriptions given in these pages prove, however, the unwillingness of the growers and refiners of sugar to remain inactive spectators of the general advancement.

APPENDIX.

OBSERVATIONS ON THE USE OF THE PLOUGH IN WEST INDIAN AGRICULTURE.

[*Extracted from a Report made to the Agricultural Society of Antigua.**]

It has always been matter of surprise to European agriculturists, and indeed to most people visiting the Colonies, that the plough is not in the same general use in the cultivation of the sugar cane, and other productions of the West Indies, as it is in the culture of wheat, potatoes, or any other production of the earth in Europe.

The objections have been referable either to the precipitous and rugged nature of the earth's surface in many of the most fertile islands, especially those which are of a volcanic

* The author is indebted to Major Moody, Royal Engineers, for the manuscript containing these observations, being considered the most valuable in the extensive collection of papers on agricultural subjects, collected by Major Moody, when in the West Indies. It may be necessary to apologize to Dr. Nugent, from whose pen these observations proceeded, for errors of composition, as the extracts were made, with the permission of Dr. Nugent, by a hired clerk of Major Moody, and having since been often transcribed for the information of planters in different Colonies, some clerical errors have no doubt been committed, and may have escaped correction.

character, formed, as they are, of a succession of steep, abrupt, and often rocky mountains, with narrow gulleys or ravines between, or else, in islands which are of a different feature, to the difficulty of supporting stock in proper condition under the labour of the plough; added to which may be mentioned the imperfect nature of the ploughs themselves, as heretofore used, speedily falling into disrepair and decay in unskilful hands, and under a tropical sun, and in countries too where the zealous experimenter either meets with no assistance from good mechanics, or else procures it at a most extravagant rate of expense. A considerable obstacle, too, has doubtless resulted from the awkwardness and inaptitude of the negro labourers themselves, and the want of steady competent persons to instruct them. Whatever may be the case with some other Colonies, fortunately the face of the country presents no obstacle to the plough in this island, as it is cleared of natural wood, and is generally level, or offering only gentle undulations of surface. The plough had accordingly long been used in those parts of the island, as in the parishes of St. John, St. Mary, and St. Paul, where the soil is of a stiff, clayey, and adhesive nature, and where the pastures are good, throwing up a strong and vigorous grass for the support of the cattle used. But even here the land, when turned up, was, for the most part, afterwards holed by the hoe, and the difficulty of supporting cattle for the double labours of carting in the crop and for working the plough was severely felt, particularly in dry seasons, and a narrow limit put to the efforts of opening land, leaving perhaps the greater part required to the exclusive operation of the hoe.

In other parts of the island, the northern and eastern, where the soil is light, where the substratum is of a calcareous and marly nature, and where only a short and scanty herbage is naturally thrown up, like that on chalky

downs in England, and where there is a great deficiency of moisture, it is with difficulty that even a limited number of oxen and cattle are kept in condition out of the crop, without any labour at all, and during the time they are supported on the recent cane top, are barely equal to perform the cartage duties of a considerable estate. The only adviseable plan, therefore, is to work the plough in these districts with horses, and the practice, as might have been anticipated from a judicious and persevering effort, has been found so beneficial as now to be common, and may be expected soon to become universal.

The amazing diminution of human labour, the more effectual turning and pulverizing the soil, than can be accomplished by the hoe, the greater quantity of land that can thus be cultivated, while the ordinary hands of the estate are diverted to the accumulation of manure, to the office of weeding, and other important purposes, above all, the advantages afforded of opening with facility a sufficiency of land during the active engagements and constant employment of the crop, for the timely planting of provisions, may, to say nothing of the moral benefits, be enumerated among the important advantages of this system. The plough which is now in most general use in this island, and which has nearly usurped the place of Plenty's and every other, is that of the excellent workman, Mr. Wilkie, of Uddiston, near Hamilton, in Lanarkshire, which, being made entirely of iron, except the tips of the handles, and of simple construction, without wheels, is strong, little liable to derangement, and calculated to last in this climate; suited as well for stiff as for light land, at the same time that it is handy and convertible to all purposes, whether of ploughing, banking, moulding, or weeding. The plough is drawn by horses, driven in hand in the Scotch or Norfolk way. In the light soils two horses have been found sufficient for the draught, and have stood well, with constant work, for nearly three

years; on other plantations, three horses, worked either abreast or with one leader, are required; and where the soils are more stubborn, four horses are found essential. Much difference in the force required depends, particularly in this climate, on the state of the soil at the time of ploughing, as to dryness and moisture, as well as on its own natural and inherent tenacity. The superior advantage of using horses abreast appears to be, that they are brought nearer the draught, require only one person to conduct them, and that they turn more conveniently, and within a narrower compass, on the head-lands. When three horses are thus used abreast, to equalize the draught, it is necessary that the plough should, by inclining the beam to the right hand, and the share and coulter to the left, take, as it is termed, one-third more land; this, of course, will not be required where four horses are used, the draught being then equal, as is the case with two.

The average cost of a pair of good farm horses here may be stated at one hundred guineas, and those from England and America have been found to answer well. The estimate of their keep for the average of the year may be stated, if oats be used, at half a bushel a day, or 183 bushels a year, which, if imported at 12*s.* currency per bushel, will give 104*l.* 6*s.* currency, to which add shoeing and veterinary charges 16*l.* making the sum of 120*l.* 6*s.* from which deduct say 30*l.* 6*s.* for value of manure, the quantity of which may be very much increased by keeping constantly cane trash under the horses in the stable, leaving thus, in round numbers, 90*l.* currency, or 45*l.* sterling, as the annual cost of keeping each pair of plough horses.*

* As oats of the best quality may now be imported into the West Indies at less than half the price here named, the annual expense of keeping each pair of plough horses will be reduced to below 20*l.* sterling.

Nothing is now more essential in using horses in the plough in this climate, than to have good and substantial harness, so made, especially in the collars, as to prevent chafing and galling; and the cost of such harness may be stated at 11*l.* or 12*l.* currency.

Many active and steady ploughmen, from Scotland, having, since the peace, been induced to come to this island, a great deal of good work has been exhibited, and a ready mean afforded of instructing negroes in the management of the plough, many of whom go through their duty in a highly creditable manner. Men selected to be brought up for this purpose, should be young, active, and intelligent, and of the best possible disposition and character, to whom an additional allowance and some little encouragement in clothing is given, in consequence of their occasional attendance in the stables on Sundays and during a part of the daily noon time. During the crop, excellent fodder is afforded in abundance for the horses from the cane top, sliced, which, at that period of the year, is not too green or succulent, but somewhat dry, and containing a wholesome and nutritious saccharine principle. After the crop, it will, of course, be highly adviseable to have recourse to some of the most approved grasses, either cut daily or made into hay. The European grasses are frequently mentioned as deserving of trial, and some of them, especially lucerne, might be found to succeed, but it seems most desirable to adopt some of those numerous fine grasses with which the tropics have been bountifully supplied by nature, more particularly the cent. per cent. and the Guinea grasses, which are extremely hardy and easily procured, either by seed or planting. Colonel Martin, with much reasoning, commends a hay, or fodder, made of Guinea corn leaves, well tedded in the sun for three or four days, and then tied up in bundles or sheaves, and which, he says, will keep good in ricks

for three or four years. On two estates in Old North Sound Division the horses are entirely fed on Guinea grass hay. The Guinea grass is planted in rows, or drills, two feet asunder, and as close as the stalks will admit. One mowing from three acres suffices for five horses, kept constantly at hard work for three months, and three or four crops may easily be procured in the year. An extension of this culture for a few acres more would yield such a superfluity of fine hay as to enable the planter to give it to his cattle during the recess of the crop. The Guinea grass, in its green state, being universally acknowledged to be most excellent food for horses, it might be supposed to answer as well if cut daily; but by taking it all in at the proper growth and curing, we avoid the possibility of using it either too young and succulent, or too old, when the stalks have become hard and dry. The hours for the plough being in the fields are from day light until half-past nine o'clock, and from three p. m. until sunset, by which the intensity of the heat is avoided. A steady employment of six or seven hours thus a day, even at three quarters of an acre, would give, for 300 working days 225 acres for one plough; an adequate reduction being, of course, made, if the same horses are employed to harrow and bank the land. On estates where there is no great quantity of land to prepare, the horses are made constantly serviceable in carting trash, mould, and manure, as well as produce to the place of shipment. The land being ploughed and harrowed, is to be thrown up in strait and equi-distant banks or ridges, and it appears preferable for this purpose to use the single mould board, instead of the double mould board, often recommended; the strain is considerably less to the horses, and, by returning down the furrow, it is deepened, the bank thrown higher, and the work rendered neater and better by correcting, in the second passing of the plough, any little

previous irregularity; a jointed mould board, by allowing a greater dilatation, will, however, enable us to throw up a more powerful bank. The distance between the crests of the banks will thus be three feet, and a space may be rendered still wider if required, by leaving a narrow bar in the banking, which is afterwards cleared out, and the earth added to the banks by a second passing of the plough; but a good workman is required to do this with precision, and the tops of the banks may thus be four feet asunder. It may, perhaps, be adviseable to plough, especially on level lands, in a north and south direction, and afterwards to bank across east and west. The trade winds then circulate freely between the banks, and all the light showers, which generally fall with some obliquity from the east, impinge fairly along the drills. In hilly lands, however, we cannot consider this, but must throw our banks so as most effectually to ease the draft, and to prevent the washing of the soil, which in many situations, may be effected by banking, either diagonally to the ploughing, or in the same direction with it. If the object be to plant yams, they are inserted by dibbling either in the sides or on the tops of the banks, and exceedingly good returns have been had from lands thus prepared, with good seed from Anguilla, equal to at least 15,000 per acre. Yam bits may also be covered in by the plough, like potatoes in Great Britain, with or without manure, and it is probable the more round and compact kinds may be reaped by the plough; the coosh-coosh, or Barbuda yam, being, perhaps, too forked and brittle for this purpose. Eddoes do well inserted in the furrows.

If the cane is to be planted, the plants may be placed either crosswise or longitudinally in the furrow, with or without bedding with the hoe, according to the nature of the soil. In light soil, nothing more is required than inserting the plants, and not too close; going in after-

wards rather early, and hand-hoeing the young sprouts, giving them a little mould, and widening the furrow or bed, by bringing down the more prominent part of the banks; occasioning thus a freer circulation of air, and contributing to the plants branching out in the stool. If it be thought requisite to widen and pulverize the bottom of the trench before placing the plant, or if it be objected that, by leaving the furrow narrow at bottom, a channel or gutter is formed for rain, subjecting the land and the young plants to be washed, especially in hilly positions, this may be obviated by the use of an appropriate instrument, scarcely differing from the drill harrow of turnip growers. This instrument is drawn by one horse, and consists of a central solid piece of hard wood, say four and a half feet long, having two arms or wings of the same hard wood, somewhat shorter, attached to its sides by a hinge, or hook and eye. These arms are capable of expanding, and being kept steady by means of a bar of iron, fixed to the near end of the central piece of wood, and passing, at its extremities, through mortices in the side pieces, in which extremities are also holes, at different distances, for bolts. In all these pieces of wood are mortices, in which are put strong harrow spikes, except in the last mortice of either wing; in these are inserted, instead of spikes, two curved coulter knives, which have the double effect of extirpating any weed that may come in contact, and of bringing down and laying in the bed such portion of the sides of the bank as may be desired. This instrument, provided with handles and made sufficiently heavy, will be found of great use in bringing the soil into a proper state for planting, and may be passed once, or oftener, up and down the furrows, or drills. A horse and one man may thus run through three or four acres a day with ease. On one plantation, where the soil is light, this instrument has even been applied with

success to covering in and planting the canes; a few young or infirm persons drop the cane plants, at proper distances, longitudinally in the drill, the harrow teeth of the central timber being then removed, the instrument is drawn along; the operation of the lateral teeth and curved knives is to cover, at the proper depths, the cane plants; the horse doing no injury to them, or at most displacing only two or three in the course of a long furrow.

Crops planted with the plough have generally turned out well, the canes being set equally straight, and less ground being lost in spaces; every part of the soil being turned, the growth is more rapid, the beds or furrows being narrow do not lie so exposed to the sun, and the young and tender plants being protected under the shade and moisture of the banks are found to stand well during drought. From the extreme facility of preparing land in this way, there may be occasionally a temptation to overplant, that is, beyond the power of weeding or manuring, but this cannot reasonably be stated as an objection to a judicious prosecution of this method of cultivation.

In such parts of the country as have a sufficiency of pasture, and where cattle can be adequately supported, it is considered preferable to plough, harrow, and bank with oxen; but it might, even here, be adviseable to bank, at least, with horses, as it is done with more expedition, and fewer hands are required; the oxen, too, would have more time to recruit. The superior neatness and solidity which, in these soils, has sometimes been attributed to the banks made with cattle, is, perhaps, owing to the nature of the soil, which lies up in a more compact mass than can be the case in a light friable mould, containing numerous cane stools, which are here turned up by the hoe, instead of being cut through and reduced by the plough, as in the stiff and clayey soils. If the prime cost and expense of keeping horses for

the plough in the marly districts. as well as the wear and incidental loss be objected to, a like number of oxen, with collars and reins, will be found powerful enough, and as tractable as horses. By coupling these animals in harness there is a much greater evenness in their draft, and, acting at the same moment with their united force, and without any degree of swerving from the straight line, they are able to perform work with less fatigue, and their exertion is rendered far more effectual than under the ordinary mode of yoking; the collars and harness are, of course, reversed, so as to bring the draft more in a line with the back of the neck, where the strength of neat cattle more particularly resides; a few oxen, stall-fed and well kept up, would doubly answer the same purposes, as in many parts of Europe; but in this part of the world, where considerable expedition is required in opening land at particular seasons for provisions and fallow crops, and that, during the busiest periods of the year, the greater dispatch of horses seems particularly desirable.

With regard to the second point under consideration, the method of applying manure to the land, it will be admitted, that however effectual in producing ultimately an active vegetation the old practice may be, that is, carrying it out after the land is holed, in baskets, on the heads of the labourers, it is, nevertheless, a process extremely tedious and irksome, and perhaps the most wasteful application of labour ever conceived, and which could only have originated where there was a great superabundance of hands, or in particular localities, as where there may have been a necessity of manuring some steep, mountainous, and rocky situations. The use of the plough, fortunately, invites to the adoption of more compendious methods of attaining the results. The most obvious one is, of course, that of surface dunging, carting in the manure, dropping it in loads

at proper distances, spreading it on the ground, and turning it into the earth with the plough; taking care, under this vertical sun, to carry out no more than what the plough may, within the day, be able to cover in. Even this method, however, will be found to have few merits, as it is more usually practised; to appreciate duly its advantages, there should be a reform in the construction of the carts and the manner of loading them. It is with much satisfaction we have recently viewed the successful efforts of several public-spirited individuals in this respect. Instead of the cumbrous misshapen carts heretofore used, and the tedious method of loading by baskets, light handy carts, which may be drawn by a single horse or ox in harness, or by two mules, are provided with one driver, who, using a three-pronged fork or spade, loads the cart himself, his foot being protected by a sandal. Such carts, which are admirably suited to this purpose of carrying out dung, and are also capable of carrying canes, mould for pens, and of transporting a hogshead of sugar, or two puncheons of rum, and which are fitted also with shelvings for large loads of trash, have been imported from Galloway, and other places in Scotland, for 14*l.* or 15*l.* sterling each, including freight and all other charges. A single horse will readily draw in one of these, on good roads, a load of twelve or fifteen hundred weight, or, for a short distance, a greater weight. The model of these carts, is recommended to those who do not import them, substituting merely, in the wheels, naves of fustic, or other hard wood.

Of course when dung is thus ploughed in from the surface, the land should lie some time before banking, that the manure may not be again turned up before it is properly decomposed, and the soil fully benefited. Some planters, perhaps from the manure not being ready in time, have waited till the banks are formed, and have then thrown

it into the drills, bedding it in with the hoe, and covering it with a portion of the mould from the sides of the banks, and thus planting on the dung; a plan which may be good, if done some considerable time before the planting, or if the manure be not too hot and recent, otherwise the cane may be expected to burn much in dry weather. In a climate which is remarkably dry, and where moisture is often deficient in the earth, it is essential, if one may use such personification, to give the plant the early habit of extending its radicles to some distance in quest of nourishment, so that when dry weather occurs it will have a wider range whence to derive moisture from the soil; this cannot be the case if it find at once a rich store in immediate contact, and during severe drought it will be deficient in the means of supplying itself with the requisite dilution. It is on this principle that, in an arid atmosphere, even under the ordinary practice of husbandry, manure, if old and of fine texture, may be better put into the bed, particularly if there is time for it to become duly mixed with the surrounding mould, and disseminated through it by frequent rains; but if the manure be long, recent, or unreduced, and especially if the ground is to be immediately planted with the cane, it had better be placed either under the holing, or cross-holing bank. It is partly under this idea, but chiefly from the extreme convenience and facility of the process in every respect, that another method of applying manure to the cane or yam crop, is most strongly recommended to the attention of planters who use the plough; it is that used in the most judicious culture of the potatoe in England and Scotland, and which experience has here proved to be highly eligible. The land, being ploughed, is to be thrown into drills of sufficient depth, either with a light double mould-board plough or the common Wilkie; no particular pains need be taken in this, and the work proceeds rapidly.

The manure is then to be dropped at stated distances, say in loads at ten feet distance. Two or three persons draw and strew the manure, whether old or new, long or short, along these drills, limiting the thickness of the application only by the quantity of dung on hand. The plough then passes between three rows of dung, covering it entirely, and raising good and sufficient banks over it; the manure being thus included in the bank, the cane plant is laid in the bed, or furrow, the decomposition of the dung is thus going on, till the growth of the plant is sufficient for it to profit by the contiguity.

The subject next in importance is that of the accumulation of those materials by which the earth's surface is ultimately rendered more productive. Considering how favourable the tropical climate, or, in other words, a combination of great heat and moisture is to the decomposition of animal and vegetable substances, and considering the importance of manure in the cultivation of so profitable a plant as the sugar cane; it is astonishing how little attention has heretofore been paid in many places to its accumulation, and how small a portion of time in the routine and progressive labour of an estate it usually occupies.* It may be regarded as one of the most prominent features in the system of ploughing and banking land in this island, that it will

* *Note by Major Moody.*—Many local causes influence the portion of labour which is devoted to the collection of matters for manure in the West Indies. In a paper published in the proceedings of the Barbadoes Agricultural Society, I estimate that 25 per cent. of all the labour annually employed on an estate in that island, was devoted to this purpose; while upon well-managed plantations under my care in Guiana, so different were the local circumstances, that no necessity existed for the expenditure of a single day's labour in the like employment.

allow of a larger portion of the year being devoted to this essential purpose. Thus, if an estate of a moderate size and means should hole and otherwise prepare sixty acres of land annually, such labour may, under ordinary circumstances, occupy sixty working days; and if forty acres of these be planted first in yams, eddoes, or some other fallow provision crop, it will, perhaps, require twenty days more to cross-hole, bed off, and otherwise dress up such proportion of land, before it be in a fit state to receive the cane; making thus eighty working days, or somewhat more than a quarter of the year, for the due preparation of sixty acres of land for the cane, under the common style of culture and by the ordinary application of negro labour. Now it is evident, that if the land be opened and dressed up by the plough, the hands of the estate may, during all this time, be diverted to the important business of accumulating manure, by gathering together, in compact masses, all scattered animal and vegetable substances, by adding liberally wash, river and seaside mould, clay, marle, soot, ashes, lees, salt, trash, seaweed, &c., and, in short, by heaping together such composts as experience may have proved to be beneficial to the soil under the culture of the cane. The result may be imagined, when all this is added to the stock of one day of the week, now usually set aside for that purpose. If it be objected that such has not been the case in any conspicuous degree on those farms where the soil is entirely dressed by the plough, it must be remembered that the system has been but lately introduced, that the difficulty every where attendant on new efforts, but more particularly in this quarter of the globe, are only now mastered, as it were, and that the results should be sought for some little time hence. Many persons, injudiciously perhaps, have been tempted rather to extend their cultivation than to apply what may now be

termed their superfluous strength to the object in question; but this implies nothing against the absolute feasibility of the thing under steadier principles.

Our method of raising manure in this part of the world is, from the opposite nature of the climate, somewhat different from that of Europe. We save less manure from the larger animals in the homestead, and more in the field. In Great Britain and other northern countries, from the severity of a long winter, during which there is a suspension of vegetation, it is necessary to protect them from the pinching effects of the season; the cattle and other live stock subsisting on fodder, previously gathered in; and littering them comfortably with straw within the homestead, by a judicious arrangement and disposition of which, a great quantity of manure is raised to be carried out in due time to fertilize the land. Here we have no season requiring this precaution; there is a never-ceasing vegetation, under a more than genial sun, and no inclemency of weather beyond the casualty of heavy rains, or those short but awful visitations of violent wind to which a tropical climate is liable at one period of the year.

Our cattle are indeed kept more in the home pens during one season of the year, which is that of the crop; but this plan it is to be feared is adopted more with the view of having the oxen and mules convenient for yoking and harnessing than from any idea of benefiting the animals, and economizing manure: at all other times, they range abroad during the day, and are gathered into the open pens or folds in the evening, which are generally placed in such fields as are next to be broken up, or require manure. It is to be regretted, where such an immense quantity of dung is thus unprofitably exhaled or desiccated in the pastures, that the cattle are not kept more housed, fully littered with trash, and fed with such a mixture of dry and succulent food as a

few judicious trials would doubtless soon render attainable. Where such large sums are expended in buildings, it is singular that convenient offices for this purpose should not have been attempted. Little more than a large and airy magoss-house, divided into stalls, would be required, and the advantages of the method would soon be found to repay the expense, if we enumerate only the prodigiously greater quantity and better quality of the manure; the greater security and improved condition and gentleness of the beasts, the easier access to them when wanted for labour, the smaller liability to trespass in a country mostly without enclosures, and all the endless vexations attendant thereon. Even on estates near the mountains, where there is a great deal of pasture, and where the animals are generally in good order, there would be much found to recommend this method; but in other districts with a marly sub-stratum, where the pastures hardly deserve the name, such is the dryness and shortness of the bite, and where there is consequently an extravagant annual loss of cattle, and where the few that survive, from hardiness and vigour of constitution, are frequently so lean and hide-bound as to afford a manure scarcely fertilizing, a practice of this kind seems to be urgently called for. The short and parched herbage of these tracts might be reserved for a greater quantity of sheep than is usually kept, for which race of animals experience shows it to be well suited, and from which by judicious penning and frequent trashing and moulding, a vast deal of manure might be produced.

Nothing can be more pleasing and profitable, as well as indicative of good general methods of husbandry, than having all the animals on an estate in high condition, and there is certainly no part of the rural affairs of this island so much neglected. With regard, indeed, to the state of our live stock, and the production of manure consequent

thereon, our situation here may not inaptly be compared to what it was in many parts of Great Britain, (as described by the best agricultural authorities,) especially in those districts which have a bleaker air and poorer soil, prior to the introduction of the turnip and clover system. The natural pastures yielded comparatively but little food, even during the summer months, and the cattle in many districts were so much reduced during winter, that half the next grass season was scarcely sufficient to restore their condition, and when the winter was long and severe, numbers perished by famine.

The vast addition to the quantity and quality of the dunghill by the consumption of clover and similar grasses, and turnips, &c., has been the means of rendering productive those inferior soils, which, under the old system of successive corn crops and naked fallow, it had become impossible to cultivate with profit; and even the fine lands have been so much benefited, as perhaps to have since doubled their return of grain.[*]

The experience of the Island of Barbadoes appears to be still more in point. By repeated cropping, the soil had become, less than half a century since, so much worn, as to be almost unproductive in the sugar cane, but by the substitution of other crops, particularly the Guinea corn, which yields, under a judicious culture, a large quantity of fodder, a system of soiling and tethering cattle was introduced, which, increasing largely the store of dung, has not only been the means of retrieving the lands, but has, perhaps, made them more productive than ever, adding, at the same time, to those numberless conveniences and resources which never fail to proceed from a due attention to the brute animals.

[*] See 47th No. of Edinburgh Review.

Our intelligent countryman, Colonel Martin, a competent judge on these points, writing about forty years ago, says, "Having thus hinted the duties of a planter to his negroes, let the next care be to his cattle, mules, and horses, for these creatures are next in degree valuable to their owner. The planters of Barbadoes (who are perhaps the most skilful of all others, and exact to a nicety in their calculations of profit and loss,) are, with respect to their cattle, the most remiss of any in all the islands, as if the carriage of canes to the mill, and of plantation produce to the market, was not as essential as any other branch of plantership. At Barbadoes in particular, the care of these animals is of more importance, because the soil, worn out by long culture, cannot yield any produce without plenty of dung."*

A reformation it would appear in this particular, as well as in the accumulation of manure, has been in Barbadoes the means of renovation, and an increased prosperity.† Fortunately the cane is not perhaps so rapid an exhauster of the soil as are the culmiferous plants, the staple crops of Europe. The proximate principles of the juices of the cane, mucilage and sugar, do not, in all probability, require for their production so rich a soil as these plants, wheat particularly, which contains gluten or a vegetable principle ap-

* Essay on Plantership.

† *Note by Major Moody.*—Having been one of the first members of the Agricultural Society of Barbadoes, I can bear testimony to the favourable change which has taken place since Colonel Martin wrote. To show this fact more in detail, two statements will be found in pages 328 to 334; one marked (A) respecting an estate in the Island of Tortola, where the plough cannot be used, and yet where the breed of cattle is far superior to the Cape de Verd breed employed in Barbadoes. The other statement, marked (B,) refers to an estate as managed in the Island of Barbadoes.

proaching in its chemical character to animal matter.* The cane too affords a great quantity of refuse leaves, contri-

* *Note by Major Moody.*—Dr. Nugent here suggests a very interesting subject of inquiry, to which I have, at different times, directed the attention of my scientific friends in the Colonies. Some years ago, it occupied my own, in conjunction with that of my highly esteemed friend, Dr. Jackson, who was then senior medical officer with the army in the West Indies, at the same time that I had charge of the Royal Engineer Arsenal, and Gun-Carriage Department at Barbadoes. In the discharge of professional duties, I had occasion to travel in the forests of Guiana, where my attention was first drawn to the consideration of the influence on vegetation of a greater or less degree of solar light and heat, as shown in its results. I found that the wood from the same kind of trees which grew on the tops of the small sand hills, was harder, heavier, and more durable than those trees, of the same appearance in other respects, which grew in the small adjoining hollows, and therefore were more shaded from the influence of solar light and heat; and also, that trees producing oil, resin, or gum, yielded more of these substances in proportion as they were exposed to the sun's light and heat.

I was then induced to make observations on the comparative qualities of pine timber produced in Canada and in Norway, where the trees are exposed to the action of different degrees of solar light and heat, during the different cycles of vegetation or circulation of the sap in those two countries.

In travelling in the Island of Madeira, I had also observed, as Virgil had done long before me, that

"Apertos Bacchus amat colles."

It was obvious, however, that the hills most exposed to the action of solar light and heat produced that wine which most abounded in alcohol. Nothing can be more marked than the difference in the qualities of Madeira wine in that respect; the wine from the north side of the hills being inferior. The same grape which in Germany produces the Hock wine, yielding about 14 per cent. of spirit, when transplanted to the southern side of Madeira, produces the Sercial wine of that island, yielding upwards of 20 per cent. of spirit, although there is no reason for believing that the soil of Madeira is

buting to the restoration of the soil, and such a close shade to the land, as favours, by the retention of moisture, their

more abundant in carbonaceous matter than that on the banks of the Rhine, which produces the Hock wine; indeed, the soil of Madeira appeared to me to be poorer than the other. There can, however, be no mistake in the different taste of the grapes—those in Madeira being much sweeter.

In almost every Island of the West Indies there are particular sugar plantations whose produce, being known by the marks on the hogsheads, commands a higher price in the market from the refiners than other sugar, on account of its yielding a greater proportion of refined, with reference to the weight of raw sugar used. It is probable that this advantage may have some connexion with the local circumstance of greater exposure to the action of solar light and heat, but combined, doubtless, with other causes which hitherto have not perhaps been fully investigated.

It would be tedious to specify many more considerations having the same object; suffice it to say, that Dr. Jackson and myself, having once directed our attention to the different effects of solar light and heat upon trees, plants, fruits, and leaves, varying in colour and in deposits of woody fibre, or in elaborations of carbonaceous, oily, or saccharine substances, we were then led to consider the operation of different degrees of intensity of solar light and heat upon the human frame, varying in the colour of the skin, the hair, &c. And after careful observation, but wherein other causes were also in action, we found, under circumstances nearly similar as to clothing, food, and duty, that the action of solar light and heat, under ordinary exposure in the West Indies, had a tendency, according to its excess or diminution, to induce different classes of diseases in the black and white races of men, and which influenced their capacity to labour in the open air; this being the point that more immediately concerned me as an officer, having many workmen of different colours and countries under my command, and employed on various kinds of labour in the torrid zone.

From the tables published by my friend some years ago, an inference may be drawn, that an excess of the action of solar light and heat on the human body, spends its morbific power more particularly

decomposition. A constant subtraction, however, of the same elements from the soil, must, of course, produce a gradual impoverishment; and it behoves us, while our lands

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in deranging those functions of life which are connected with the *liver* in the white race of mankind; while any considerable diminution in the intensity of these natural agents acts with comparatively greater morbific effect in deranging those vital functions which are connected with the *lungs* of the dark-skinned race of men. The effects of a diminution of solar light and heat on the lungs of monkeys and of an excess thereof on the wool of sheep are well known.

From these observations, the wisdom of the Almighty may be seen, in adapting each variety of his creation to the different countries and climates of the earth which it generally inhabits; but although we clearly see the hand of Providence, we cannot so clearly see its working, nor how many conspiring causes are employed in the production of one effect. It is probable, however, that the dark substance forming the *rete mucosum* of one variety of the human species may be intended as a provision against those diseases to which, in warm climates, that variety is more particularly exposed; and the agency of solar light and heat on such skins may be observed in the oleaginous perspiration of the negro, as well as in the oil and gums of trees, and the increase of saccharine matter in canes and grapes when exposed to the same causes. Future inquirers may perhaps ascertain that solar light under certain affinities with heat, acting on vegetable and animal juices, may form chemical combinations by which carbon is developed in such varieties of proportions as may help to explain more fully the effect and action of those various laws of nature, our knowledge of which is hitherto so imperfect.

But whatever may be the result as to the effect on human life, there cannot be any doubt but that some agent of nature acts in the West Indies more powerfully than in our climate in producing such enormous masses of vegetable matter from comparatively small portions of soil, which, upon analysis, does not appear to contain the principles of fertility in a much greater degree than our own. To discover in what this agency consists, is surely an object worthy the pursuit of a liberal mind, and the investigation is therefore recommend to the scientific planter who may peruse this note.

are still good, to provide amply the means not only of their support, but of their still greater invigoration. For this essential object, nothing can be so requisite as the introduction of some kind of crop capable of subsisting animals to the fullest extent, and which shall be as a substitute for the green crop or soiling system of Great Britain. This cannot be too strongly inculcated as the great consideration in the field culture of our Island.

During the continuance of the sugar harvest, we have the means of subsisting our live stock, (though even then the custom is often to neglect them much,) from the cane tops and scum, but the moment the mill ceases to roll, our winter for the unfortunate animals commences. They are permitted to roam over what are termed pastures, but where a blade of grass is scarcely to be perceived, especially in those long droughts to which we are subject, and on the approach of night are served with dry cane tops, or, what is worse, dry cane trash, and which nothing but their starving condition would prompt them to eat, and during hours which ought to be devoted to their rest; such at least is the case in the northern and eastern parts of the Island, the most populous and otherwise the most productive.

What a general amelioration might be expected if those animals were amply subsisted by day as well as night on some nutritious food! How much would the cattle be improved, how much greater their labour, what an addition to the domestic comforts of the planter, what a saving of expense in the purchase of beasts, and, above all, what an additional fund of manure for the principal and gainful crop. While all are convinced of the truth of this, no one has yet the resolution to plant what may be entirely devoted to fodder, from the mistaken apprehension, as it would seem, of injuring the cane land; nor, indeed, are planters yet agreed what would be the most suitable plant to culti-

vate for this purpose. Since the decline of rattoon canes, a certain degree of soiling has been adopted by their means, without being reserved, as formerly, to make part of the ensuing crop; they are, or rather a certain proportion of them are, in most places, successively destroyed before attaining to maturity, by which the pens are saved to a certain degree, and the lands prepared early for another crop, after a short fallow, or after receiving some manure.

This soiling has so good an effect in keeping up the cattle, that many planters think the cane itself would thus afford the best soiling material, and it is a striking feature, certainly, in this admirable plant, that while it yields the staples for which it is more particularly cultivated, sugar, rum, and molasses, it gives at the same time, not only fuel in abundance for the evaporation of its own juices, but also litter and the wholesomest food for all classes of brute animals; but in the way the rattoon sprout is used, it is altogether insufficient as a soiling crop, and by retaining it growing in the earth, a certain exhaustion, as regards succeeding crops of the same plant, must be the consequence. The purpose is rather to grow something which, answering the desired end, shall act also as a relief to the land on withdrawing the sugar cane; whoever shall introduce a species of culture of this sort, will be considered as a benefactor to the Colony. Of the European products, tares, lucerne grass, buck wheat, and maltese clover, appear to promise the greatest success, as being most suited to the soil and climate; but, in all probability, Guinea corn and Guinea grass, in increased quantity, will be most successfully adopted in aid of the rattoon sprouts, for the purpose in view, and may be found sufficient for the number of animals ordinarily kept. The cane-top cutters are highly serviceable during the crop, as leading to a more economical consumption, but an implement which should cut the cane-top longitudinally, instead of transversely, is still more to

be desired; at present the slices are short, containing each a section of the hard central stem of the leaf, impeding mastication in some degree, and the fodder thus obtained must be put into a trough, and can only serve for immediate use; whereas, if the tops were cut lengthwise and very fine, they would be very flexible and tender, giving the cattle a longer bite, and they might, perhaps, be cured into good hay, to be stacked and reserved for time of need.

To raise manure abundantly from animals, it is, of course, essential that they should have a sufficiency of suitable food, and that they should be amply served with fresh trash for litter, not only that they may be clean and comfortable, but that it may be trodden down into dung for this purpose. We can scarcely put up too many top and trash heaps, for which office the many calm days during the crop offer sufficient leisure. Many planters, with the idea of increasing the quantity of manure, pen their cattle in the middle of the day as well as at night, a practice which would be highly commendable if they gave the animals something to eat at the same time, and preserved them in summer from the raging influence of a noontide tropical sun, otherwise this additional quantity of manure may be acquired at too dear a rate. The method of folding cattle in the strict sense, moving them over successive portions of the land is not very prevalent here, but has been adopted by some planters, especially in Bermudian Valley and New Division, with eminent success, occasioning a fine succession of rattoons even to the third crop. The chief obstacle to this method is the want of secure and solid enclosures, which may be readily moved without the labour of digging holes for the insertion of the posts; those of iron, imported from England, in all probability, from a misconception of the orders, have failed entirely, but different plans of great simplicity may, doubtless, be suggested for this purpose.

Much manure is made from the goats, hogs, rabbits,

poultry, and other live stock, kept by negroes, of which little account is, for the most part, made; a rummage being only occasionally resolved on during some moment of extraordinary activity. It would be better if this came to be regarded as part of the regular annual supply of manure, and was never overlooked; a great deal of that which is now, by long neglect, exhaled by the sun, or dissipated by the wind and rain, would be preserved; the comfort and cleanliness of the people would be increased, and their little enclosures and gardens, which are now mostly too rank and rich, especially in so dry a climate, would be made more productive. It must be confessed that the crowded and irregular way in which the negro-houses are, from the wayward and capricious choice of those who inhabit them, frequently built, is an obstacle to removing this essenti of the fund of manure from them; but, in some they are so disposed, that wheel-barrows, or light c carts, which turn in small spaces, either have access, or a narrow lane may be made between each row of houses so as to give them access. At all events such an arrangement should be kept in view wherever a rebuilding, either from fire or gales of wind, is necessary, and the manure should be taken away in the mean while by any possible approach. The parade and ostentation of carrying out dung and gathering it into imposing heaps, as frequently practised, cannot, of course, be generally commended, as a double labour may be created thereby; but if such dung from previous drought, and from not having had a due degree of mould, be not sufficiently decomposed, it may very properly be thus heaped in the field, moulding it as we proceed, and waiting the period of maturation, if one may so speak. Besides mere animal manure, there are, of course, many important auxiliaries, in rendering the soil more fertile, which are to be made use of with unremitting industry.

" Mould, dug from ponds, creeks, and gulleys, is to be constantly added to the dung and trash accumulating in the pens. Such mould, not only by imbibing the soluble parts of the dung, adds materially to the quantity of manure, but has a good effect in preserving from evaporation the moisture so necessary for the rotting of the trash in the subsequent layers of the heaps. Recent experience, too, has proved that thick, adhesive, brackish earth, which is found under the mangrove trees on the sea shore, and which seems to have been formerly neglected, on account of the strong impregnations of salt, is possessed of the most fertilizing properties, especially when it is first exposed for some time to the air, and passed afterwards through the pens. It is to be admitted that if the earth made use of be good in itself, it is scarcely conceivable that the pens can be moulded too frequently, though many intelligent planters are of opinion such may be the case, and confine themselves to moulding once a week or fortnight; the solution of the question must depend altogether on the nature of the earth used to mould with, and on the state and condition of the land to be dealt with. Perhaps with lands that are in heart, a more frequent and more extensive manuring with a compost which does not contain an extensive portion of rich animal matter, may be more suitable than only an occasional application to a smaller quantity of land of a richer material; for the planter, it must be remembered, has now more than ever to consider the quality as well as the quantity of his sugar. Some years ago most planters here had a dread of turning up the marly substratum, but later experience has shown the good effects of a liberal application of this substance, especially in stiff black loams, and where, for a succession of years, large quantities of cane trash have been holed into the ground, it is successfully applied, either turned in on the surface by

itself, or passed through the cattle pens. Independently of the mechanical benefit to the soil, by making it more divided and pulverulent, as well as more capable of absorbing moisture and of adjusting in due proportion the component parts of the soil, marls, probably like lime, tend to reduce the carbonaceous parts more quickly into the state required for the food of plants, and, indeed, no doubt contain of themselves a considerable portion of animal and vegetable matter, as might be inferred from the quantity of shells and other exuviæ which are found imbedded in and incorporated with them, and from the support which they exclusively give in many places to large trees and shrubs. This is more particularly the case with the marly beds of this island, which, like those in the vicinity of Paris, the Isle of Wight, and some other parts of the world, owe their origin to the more recent revolutions of the earth's surface, and which, like them, contain not only a profusion of testaceous remains, but a singular admixture of marine with fresh water or terrestrial shells, seeming to indicate that the beds of marl have been produced from the washings, as it were, from the earth's surface during some former state of its existence. It is of considerable importance to make a good selection of the marl, which is to be applied in an agricultural point of view, as some kinds are evidently more fertilizing than others, and in many places the good and inferior sorts are to be found within a few yards distance of each other.

There is a gritty sort of yellowish marl, with ferruginous streaks, which should rather be avoided: there are other kinds containing the principle of the gall or yellow patch, a curious subject to which our attention may hereafter be directed; there is also a pure white friable marl, which, containing little else than the mere carbonate of lime, can add no other virtue but what is contained in that substance.

The best will be found to be that sort of marl of a light yellowish colour, which is replete with shells, the most common of which are species of helix, bulimus, and donax, and which, independently of some argillaceous earth and the carbonate of lime, appears to contain also no small portion of animal and vegetable matter. Under all circumstances it is found that marls are better for being dug and exposed to the air sometime before their application. In the stiff and clayey soils the use of marl is, perhaps, too much neglected: its use in these districts would indeed be attended with considerable cartage, but this may be found to repay here as well as in England, where this substance is frequently procured with great pains and expense, from a considerable distance. In these soils, too, lime is, perhaps, too much overlooked: it would tend much to lighten and divide the soil, as well as to subdue nut grass and other weeds, and by destroying their vital power to make them contribute in their turn to the enriching of the earth. But there is another substance within the reach of many estates possessed of the adhesive soils, which is more attainable, and which is, nevertheless, strangely disregarded. We mean the calcareous sand on the sea-shore, made up entirely of minute fragments of shells; a kind of manure eagerly sought for in Europe, and which would tend greatly to the improvement of many soils of the country. The experiments of several zealous and intelligent individuals have not been wanting in endeavouring to ascertain the productive powers communicated to our soil by those methods, which have recently attracted notice in Great Britain, especially clay burning, the application of compressed light soil, and desiccated compost, and of soot, to the extent of seventy or eighty bushels per acre. The good effects of these have been manifest, though, perhaps, insufficiently striking to induce the planter, in the present state of his resources, to continue the trouble and expense

attendant thereon. But a very cheap and valuable auxiliar is likely to be found in salt. Many trials have now, durin successive seasons, been made of this substance, generally to the extent of about nine or ten bus acre, and, whatever may be the result of those discu which are now warmly revived in England, with regard salt, there can be no doubt but that it will prove of grea importance in the cultivation of the cane at least, by destroying the grub and other insects, and by giving an increased vigour of growth and ability to resist drought. It is a singular remark of the intelligent traveller M. de Humboldt, while speaking of the practice used in the missions of the Orinoco, in planting cocoa-nut trees, of throwing a certain quantity of salt into the hole which receives the nut, "that of all the plants cultivated by man there are only the sugar cane, the plantain, the mammea, and the avocada pear, which have the property of enduring equally to be irrigated with fresh and salt water."

M. de Humboldt has, in all probability, circumscribed too much this enumeration of plants, but it may lead to important results, should his idea with regard to the sugar-cane prove to be correct. Salt is evidently a manure which must be used with discretion, and future experience must decide what are the proper rules and limits for its application. The method of improving land by turning into the soil a growing green crop has, of course, frequently occurred to planters here; and the palma christi particularly, has been recommended as a suitable plan for that purpose; but many methods and practices more essential and urgent, claim, perhaps, a priority of attention over the more refined and elaborate systems in agriculture.

(A.)

ESTIMATE OF THE PRODUCE AND EXPENSES OF A SUGAR ESTATE IN TORTOLA, SHOWING THE RATES OF PROFIT ON STOCK.

Extracted from the "Second Part of Major Moody's Report relating to Captured Negroes." Printed by order of the House of Commons, February, 1826.

Description of the Situation of the Estate, Soil, &c.

It is situated in the S. W. division of the Island of Tortola, bounded by the sea, and about nine miles from town. The variety of the soil on this Estate is so great, that it is difficult to give an accurate description of it, the greater part, however, is light brown and black loam, rather rocky, and hilly.

ESTIMATED VALUE.

	£.	£. s. d.
89 Negroes per appraised value	at 100	8900 - -
135 Acres in land for canes	35	4725 - -
55 Ditto in Negro grounds and gardens	15	825 - -
267 Ditto in pasture, and uncultivated	6	1602 - -
3 Steers	22	66 - -
1 Horse	—	41 5 -
21 Mules	33	693 - -
Buildings and utensils	—	4500 - -
Total Tortola Currency		21,352 5 -
At 200 per cent. Exchange, total Sterling		10,676 2 6

Rate of Profit on Stock about 2¼ per cent. per annum.

N. B.—I place great confidence in the accuracy of these data given by the receiver appointed by the Court of Chancery to take charge of the plantation. The accounts, therefore, would be publicly examined. The sums given are designedly intended to be *average* rates.

GENERAL VIEW of the Sugar Plantation in Tortola, called · in the year 1823.

CULTIVATION AND PRODUCTION.	acres.	PRODUCE. SUGAR. Hhds. of 1,500 lbs.	RUM. pun. galls	PRICE of each Arti Currency.	AMOU Curren l.
'lant canes	15	80	40 4400	Sugar per hhd. l. 24	1920
Rattoons	120			Rum per gall. 2s. 3d.	495
Negro grounds and gardens	55				
Pasture and uncultivated	267				
	457			Gross Produce	l. 2415

CONSUMPTION AND EXPENSE.

t Gang Negroes	38	Ration	Rations per week allowed according to a &c. to slaves, in addi to the produce of their grounds and gardens:— Corn meal from two to three quarts; herrings, six; valued under the charge for food issued.
d Ditto	29		
d Ditto	16		
nfants	[illegible]		

'alued at

FOOD ISSUED.	Average Annual Cost in Currency.
alt	3 6 . .
barrels pork, for Christmas allowances	24 15 . .
barrels flour, for Christmas allowances	20 12 6
5 ditto herrings	103 2 6
0 puncheons corn meal	264 . . . .

	415 1
undry for sick	50
lothing	100
Doctor's charges	50
nager's salary	250
ceiver's ditto	175
lonial and 4½ pc. ..... tax	155
Deal, lumber, for cane spouts and heading	120
taves and wood hoops	180
amp oil and temper lime	35
Hoes, bills, and nails	75
ron hoops and rivets	25
Workmen's account and repairs of buildings	100
Decrease of stock	100
Miscellaneous charges	50
Total Expenditure	l. 1917
Net Revenue in Currency	l. 497 16
Exchange at 200 per cent. Net Revenue in Sterling	l. 248 1[illegible]

(B.)

ESTIMATE OF THE PRODUCE AND EXPENSES OF A SUGAR ESTATE IN BARBADOES, SHOWING THE RATES PROFIT ON STOCK.

Extracted from Major Moody's Report.

Description of the Situation of the Estate, Soil, &c.

The parish lines of St. George, St. Thomas, and St. Joseph, run through this Estate. It is distant seven miles from Bridge-Town, where the sugar is sent. The soil is a light brown and red loam, and is tolerably free from stones. The sea is about five miles from the nearest point.

ESTIMATED VALUE.

	£		£
150 Negroes, valued at	90	each	13,500
216 Acres	80	....	17,280
98 Ditto	50	....	4,900
80 Grown Cattle	15	....	1,200
16 Steers	10	....	160
16 Calves	5	....	80
10 Horses	60	....	600
Buildings and utensils		....	5000
		Total Barbadoes currency	42,720
		Total Sterling at 133⅓ per cent	32,040

Rate of Profit on Stock during the price of Sugar as quoted in the Estimate being 37*s.* 6*d.* sterling per cwt. from its superior quality:—about 9 per cent. per annum.

N. B.—The above plantation is very seasonable, produces fine sugar, and affords a fair specimen of the management followed in the Island. The prices are the average rates selected from actual sales. The general profits on stock throughout the Island (where the lands are not so seasonably situated to benefit by the showers of rain) fall

short of this, which has been selected to show, in minute detail, the rather peculiar mode adopted in Barbadoes, for cultivating the ground, and feeding the slaves, when compared with the system adopted in Tortola ; yet the two statements require some explanation. In Tortola the slave has land given to him, and American corn flour is purchased cheaper than it can be raised and ground into meal in the Island. The vicinity to a foreign Island gives the slave in Tortola the means of exchanging his stock of poultry, pigs, &c., and the produce of his ground, to advantage, by receiving the productions of the United States, by smuggling in return. These measures could not be resorted to in Barbadoes, where the population also is greater with relation to the extent of good soil, so that the proprietor, by means of his capital, and superior arrangements for the subdivision of labour, is enabled to produce much larger crops from the same space of soil to feed his slaves, than if he left his slaves to cultivate the small space of ground which he could afford to give them to work thereon for themselves. Local peculiarities occur in every Island, influencing the system of each, and which cannot be readily understood by persons ignorant of local details, which it is equally tedious to give as they are difficult to understand, as bearing on questions connected with the controul of labour, by persons who never have had any experience therein.

I place great confidence in the accuracy of the data here given, from the particulars being furnished by the attorney of the estate, from the plantation books which had been transmitted to the proprietors residing in England. My own knowledge of the details of a sugar plantation enabled me to point out any error. The superior quality of the produce of this estate justifies the high price. The quantities of provisions are partly computed from the deliveries on the estate,

GENERAL VIEW of a Sugar Plantation in the Island of

CULTIVATION.	Acres.	PRODUCE. Sugar Hhds. of 1600 lbs.	Rum. galls.	Molasses. galls.	Guinea Corn. bshls.	Indian Corn. bshls.
Plant canes	33	116	5216	1600	.	.
Rattoons	33					
Nursery	6	.	.	.	.	.
Guinea corn	70	.	.	.	1050	.
Indian corn	20	.	.	.	.	250
Sweet potatoes	20	.	.	.	.	.
Yams and eddoes	17	.	.	.	.	.
Pumpkins and ochroes	2	.	.	.	.	.
Pigeon pease and bonavis	15	.	.	.	.	.
	216					
Artificial grasses	25					
Negro gardens	9					
Tenants	10					
Pasture and uncultivated	54					
Acres	314	116	5216	1600	1050	250

NEGROES CONSUME.	Negro's	Rations				
Men and women	86		Pr. diem: 2 pts. Guinea corn, or $2\frac{1}{2}$ Indian.			
2d Gang, girls and boys	20		Do.	do.	do.	
3d Gang	18		Do. $1\frac{1}{2}$ Guinea, or 2 pts. Indian.			
Play gang	15					
Infants	11		Do. 1		do.	
Negroes	150 use	$\frac{1}{2}$	100	1400	800	
Family and white servants, with the horses, horned cattle, and stock of every description, &c. consume, except what is used for plants or seed		$\frac{1}{2}$	50	200	250	250

FOOD ISSUED.	£. s.					
60 qtls. salt fish, at 35s. per	105 0	.	.	.	.	.
3 barrels pork, at 22s. per	22 10					
60 bushels salt, at 5s. per	15 0					
Sundries for sick	30 0					
Clothing	.	.	.	.	.	.
Doctor's charges	.	.	.	.	.	.
Salaries	.	.	.	.	.	.
Colonial and $4\frac{1}{2}$ per cent. taxes		.	.	.	.	.
Feeding white servants, besides vegetables, consisting principally of pork fed and corned on the estate		.	.	.	.	.
Deal lumber and staves	.	.	.	.	.	.
Workman's accounts	.	.	.	.	.	.
Hoops and temper lime	.	.	.	.	.	.
Repairs of buildings	.	.	.	.	.	.
Miscellaneous charges	.	.	.	.	.	.
		1	150	1600	1050	250

Barbadoes, consisting of 150 Negroes, and 314 Acres, in 1822.

PRODUCE.					PRICE of each Article in Currency of Barbadoes.	AMOUNT in Barbadoes Currency.		
Sweet Potatoes.	Yams.	Eddoes.	Pumpkins and Ochroes.	Bonavis and Pease.				
lbs.	*lbs.*	*lbs.*	*lbs.*	*bushels.*		*l.*	*s.*	*d.*
.	.	.	.	.	Sugar, £ 40 per hhd.	4640	..	..
.	.	.	.	.	Rum, 2*s.* 8*d.* per gallon	695	9	4
.	.	.	.	.	Molasses, 2*s.* .	160	..	..
.	.	.	.	.	10*s.* per bushel .	525	..	..
.	.	.	.	.	7*s.* 6*d.* per ditto .	93	15	..
120,000	.	.	.	.	7*s.* 6*d.* per cwt. .	450	..	..
.	60,000	50,000	.	.	7*s.* 6*d.* per ditto .	412	10	..
	.	.	15,000	.	7*s.* 6*d.* per ditto .	56	5	..
.	.	.	.	200	12*s.* 6*d.* per bushel	125	..	..
120,000	60,000	50,000	15,000	200	Gross Revenue	£7157	19	4
					Potatoes and all vegetables served out at the rate of 3 lbs. to a pint of Guinea corn: and part given, after being cooked, as a dressed meal, with meat or fish, and part given in kind, according to the wishes and character of the slave. The dressed meal is given in addition to the rations.			
67,512	40,000	30,000	12,000	150	. . .	1227	15	.. ¾
52,488	20,000	20,000	3,000	50	About 10,000 lbs. weight of yams and eddoes are used for plants.	654	14	11
.	.	.	.	.	. . .	172	10	..
.	.	.	.	.	. . .	150	..	..
.	.	.	.	.	. . . .	80	..	..
.	.	.	.	.	. . .	230	..	..
.	.	.	.	.	.	247	..	..
.	.				. . .	50	..	..
.	.	.	.	.	. . .	140	..	..
.	.	.	.	.	. . .	50	..	..
.	.	.	.	.	. . .	50	..	..
.	.	.	.	.	. . .	100	..	..
.	.	.	.	.	. . .	50	..	..
120,000	60,000	50,000	15,000	200	Total Expenses	£3201	19	11¾
					Net Revenue in Barbadoes Currency	£ 3955	19	4¼
					Exchange at 133⅓ per cent. Net Revenue in Sterling	£2966	19	6

The statements (A) and (B) may be more easily compared by perusing the following abstract.

	Estate A	Estate B
No. 1. Number of Negroes upon each estate	89	150
2. Number of Acres planted in canes	135	72
3. Number of Acres in Negro grounds and gardens	55	9
4. Number of Acres in pasture, or uncultivated	267	54
5. Number of Acres in artificial grasses	—	25
6. Number of Acres in Indian and Guinea corn	—	90
7. Number of Acres in sweet potatoes, yams, Eddoes, &c.	—	54
8. Number of grown cattle, steers, calves, horses, mules, &c. making manure, &c.	25	122
9. Number of pounds of Sugar made per ann.	120,000	185,600
10. Number of Gallons of Rum ditto	4,400	5,212
11. Profits of Stock, as per appraised capital, per cent.	2½	near 9

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